CANADIAN ELECTRONICS ENGINEERING

MARCH 1958
A Maclean-Hunter publication
five dollars a year

AUG 22 1958

Planning cuts instruction book costs 14

Circuit designed for high voltage gain from transistors ... 20

Three-channel tape recorder monitors test flight talks ... 22

Electrostatic speakers provide live sound 26

Transistor surface research helps improve reliability 30

Packaged broadcast console simplifies installation 34

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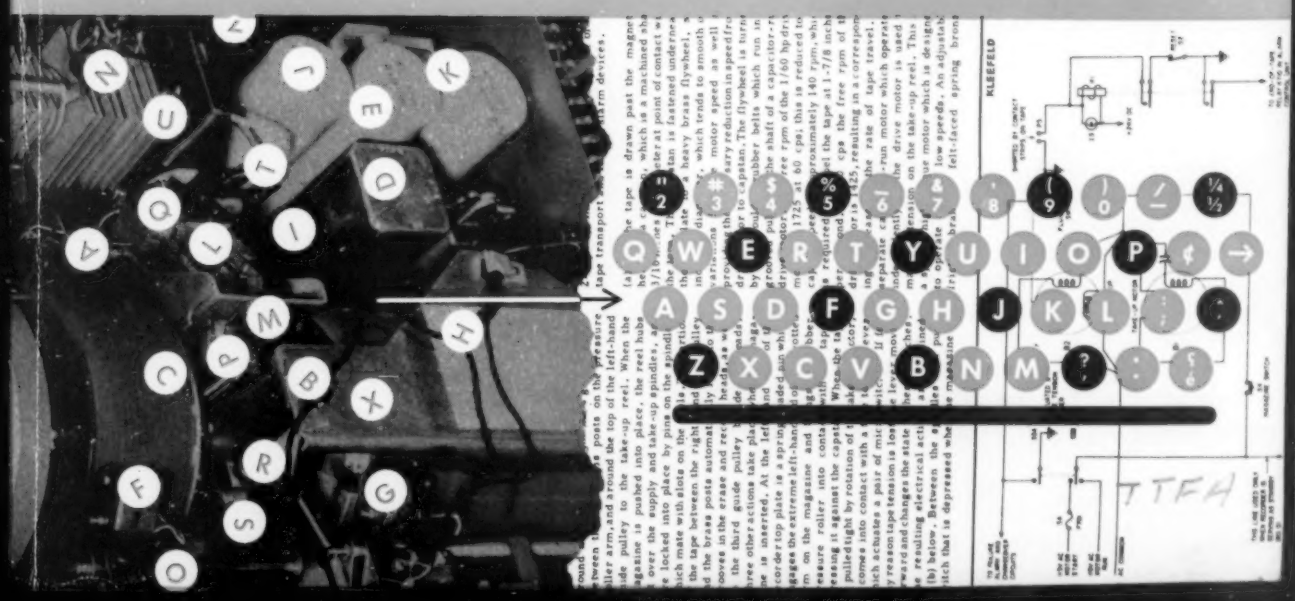

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None of the books will tell you this, but the Trojan War was really brought to an end by radar.

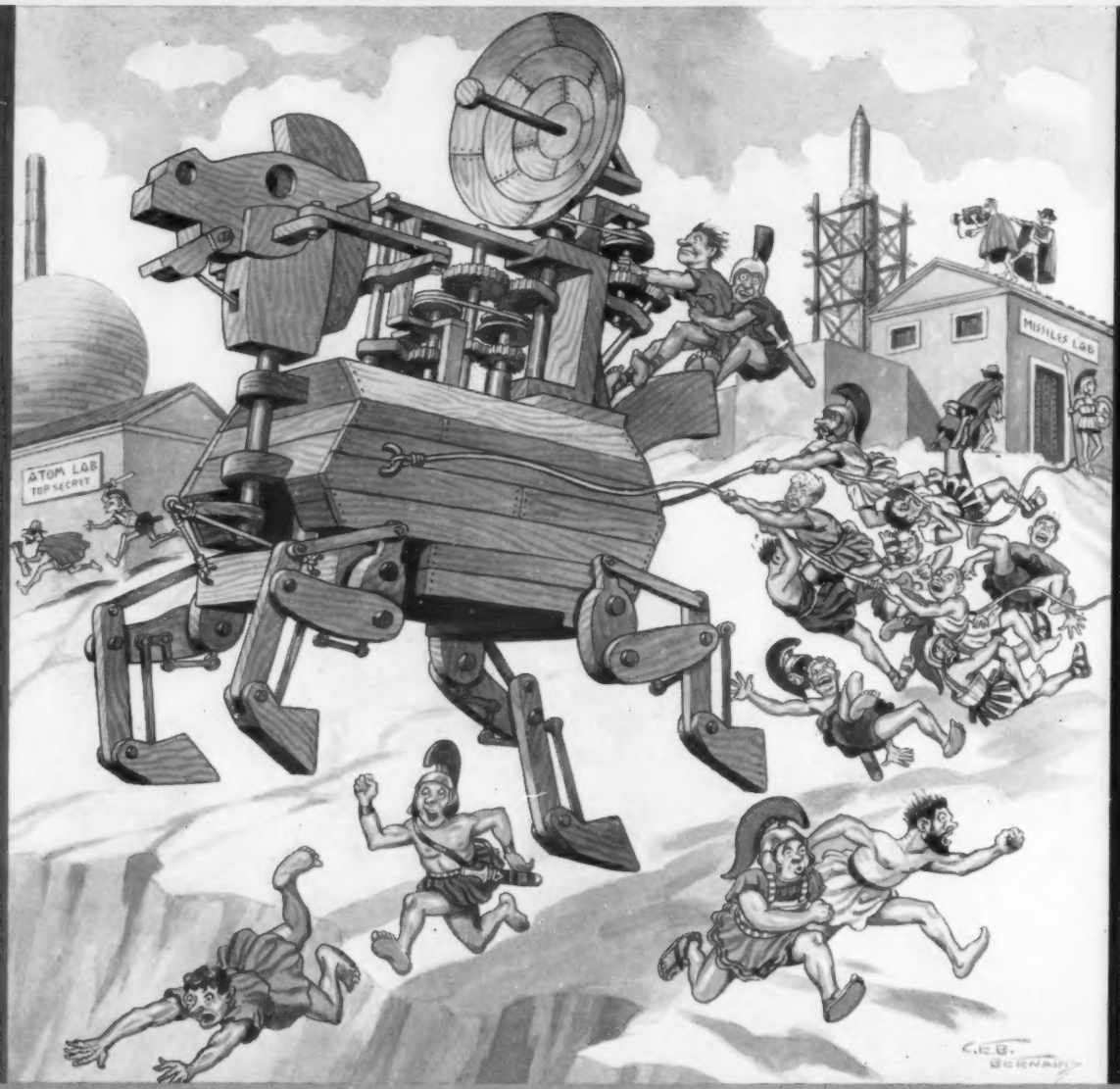
Fact is, the Greeks intended to use a radar-controlled horse as a super-weapon against the Trojans. But the scientists assigned to Project Phony Pony never were able to make it work (faulty tubes, someone said) — which made the Greek commander Odysseus so mad he had all the scientists sealed up inside the horse and left for dead outside the gates of Troy.

The curious Trojans, neglecting to look this gift hearse in the mouth, dragged it inside the city — their last mistake of the war. That night the scientists managed to escape and open the gates of the sleeping city for the Greek Army.

No one could have been more surprised at this unexpected victory than Odysseus — but he managed to squelch the real story and claim all the credit for himself. Which goes to show that people haven't changed much in 3500 years.

*But tubes have.**

No. 3 of a series... **BOMAC LOOKS AT RADAR THROUGH THE AGES**



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March 1958

CANADIAN ELECTRONICS ENGINEERING

Volume two, number 3

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***our cover design** *Letters of the alphabet appear in random confusion, like a scattering of electrons, until organized by the technical writer into a significant story. This was the theme used by our March cover artist*

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Contributors and special articles in this issue:

C. G. B. Garrett (Research into transistor surfaces helps improve reliability) is a native of Ashford, Kent, England. He received the BA degree from Cambridge University (Trinity College), in 1946, and the MA and PhD degrees, also from Cambridge, in 1950. He was an instructor in physics at Harvard University from 1950 until 1952, when he joined Bell Telephone Laboratories. Prior to 1952, his principal research was in the field of low-temperature physics, with particular reference to paramagnetics. At the Laboratories, he has been engaged in research on semi-conductor surfaces.

Garrett

Price

With his third article in CEE **Maurice Price** (Circuit designed for high voltage gain from transistors) certainly deserves a picture. Maurice, who came to Canada from South Africa via England had a flourishing beard at the IRE Canadian show but has since returned to looking more like the photograph above.

Since arriving in Canada in 1955 he has been associated with Computing Devices of Canada Ltd. as a product design engineer, working mainly in the field of aircraft instrumentation.

Team work was carried right through from the design project to the technical paper on Three-channel tape recorder monitors test flight talks. **P. A. Hallum,** a Torontonian, joined Sonograph Engineering & Manufacturing Co. Ltd., directly after graduation from the University of Toronto, Electrical Engineering, in 1955.

English member of the team, **C. C. Day,** comes from Sussex. After being educated in England and Switzerland, he gained experience in the armed forces doing radar, computer, servo mechanism work and maintenance of ground to air defense equipment.

Mechanical problems of the recorder became the responsibility of **J. N. Turnbull,** a graduate in Mechanical Engineering from the University of Toronto. Not content with his daily work load, Mr. Turnbull has enrolled in night classes to study the German language, and the Engineering Institute of Canada course on professional development.

From weather reporting to designing broadcast studio equipment may appear to be a long jump, but then, **Ken MacKenzie** (Packaged broadcast console simplifies installation) should be used to long jumps by now. Just prior to World War II, as a member of the Fort William Flying Club, he took a parachute packing course and proved his ability the hard way.

The early part of the war was spent with the Department of Transport, Meteorological Div., doing both weather reporting work and secret coding for the armed forces.

After six years as maintenance engineer for radio station CKEY, Toronto, Mr. MacKenzie joined McCurdy Radio Industries as senior project engineer.

MacKenzie

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Authorized as second class mail, Post Office Department, Ottawa.

Printed and published by Maclean-Hunter Publishing Company Limited. Editorial and Advertising Offices: 212 King Street West, Toronto 2, Canada. Address all correspondence: P.O. Box 100, Toronto, Canada.

Horace T. Hunter, Chairman of the Board; Floyd S. Chalmers, President; Donald F. Hunter, Vice-President and Managing Director.

Publishers of National Magazines in Canada: Maclean's, Chatelaine, Canadian Homes and Gardens. Business newspapers: Building Supply Dealer, Bus and Truck Transport, Canadian Advertising, Canadian Automotive Trade, Canadian Aviation, Canadian Electronics Engineering, Canadian Grocer, Canadian Hotel Review, Canadian Industrial Photography, Canadian Machinery, Canadian Missiles and Rockets, Canadian Packaging, Canadian Paint and Varnish, Canadian Printer and Publisher, Canadian Shipping, Canadian Stationer, Civic Administration, Design Engineering, Drug Merchandising, Electrical Contractor, L'Epicier, The Financial Post, Fountains in Canada, Hardware and Metal, Heating and Plumbing Engineer, Home Goods Retailing, Marketing, Men's Wear, Modern Power, Office Equipment and Methods, Painting and Decorating, Le Pharmacien, Photo Trade, Plant Administration, Le Quincaillier, Style. Business newspapers in U. S. and U.K.: Inland Printer, Rock Products, Concrete Products, British Printer.

Other services: The Financial Post Corporation Service; Canadian Press Clipping Service; Commercial Printing Division.

Offices at 1242 Peel Street, Montreal; Room 1004, The Burrard Bldg., 1030 West Georgia Street, Vancouver 5, B.C.; Maclean-Hunter Limited, 125 Strand, London, England.

Subscription rates: Canada $5.00 per year, two years $9.00, three years $12.00. Single copy price $1.00. U. S. A., United Kingdom, $10.00 per year; all other countries, $20.00 per year.

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News highlights . . .

Students to get more computers . . .

Increasing use of electronic computers in Canadian universities was highlighted recently. Managing director Richard Moonan of Pioneer Electric Company, Winnipeg, presented the University of Manitoba with his company's cheque for $32,000 to be used in the purchase of a computer. It was also announced recently that the Universiy of Toronto are purchasing an IBM 650 tape system to replace the original FERUT machine.

Defense construction estimate given . . .

Announcement by Prime Minister Diefenbaker that estimated defense construction expenditure in the 1958 calendar year would be $80,000,000 may be a pointer to level of other defense spending. The 1958 figure compares with $160,000,000 contained in the DDP estimates for the fiscal year which ends March 31, prepared by the former Liberal Government.

Soviet journals to be translated . . .

Rapidly growing interest on this side of the Atlantic in the results of the work of U.S.S.R. scientists and engineers was underlined by the recent announcement that complete English translations of four leading Soviet electrical and electronic journals will be made available. Translations will be done by the Pergamon Institute, New York.

Engineering faculty for McMaster . . .

Establishment of a faculty of engineering has been authorized by the senate of McMaster University, Hamilton, Ontario. Nominations have been made of a dean of engineering, but names are not yet released pending official confirmation from the board of governors.

Automation brings its problems . . .

Current dispute between Canadian National Telegraphs and employees operating new reperforating switching equipment may be an indication of more in the future involving use of automatic machines in various industries. The dispute, which has gone to a federal arbitration board, concerns the classification and wage-rate of the operators.

RETMA: Panel on industrial relations . . .

The Components division of RETMA had a panel discussion on industrial relations after concluding formal business at its recent meeting. Industrial relations problems peculiar to small plants received special attention.

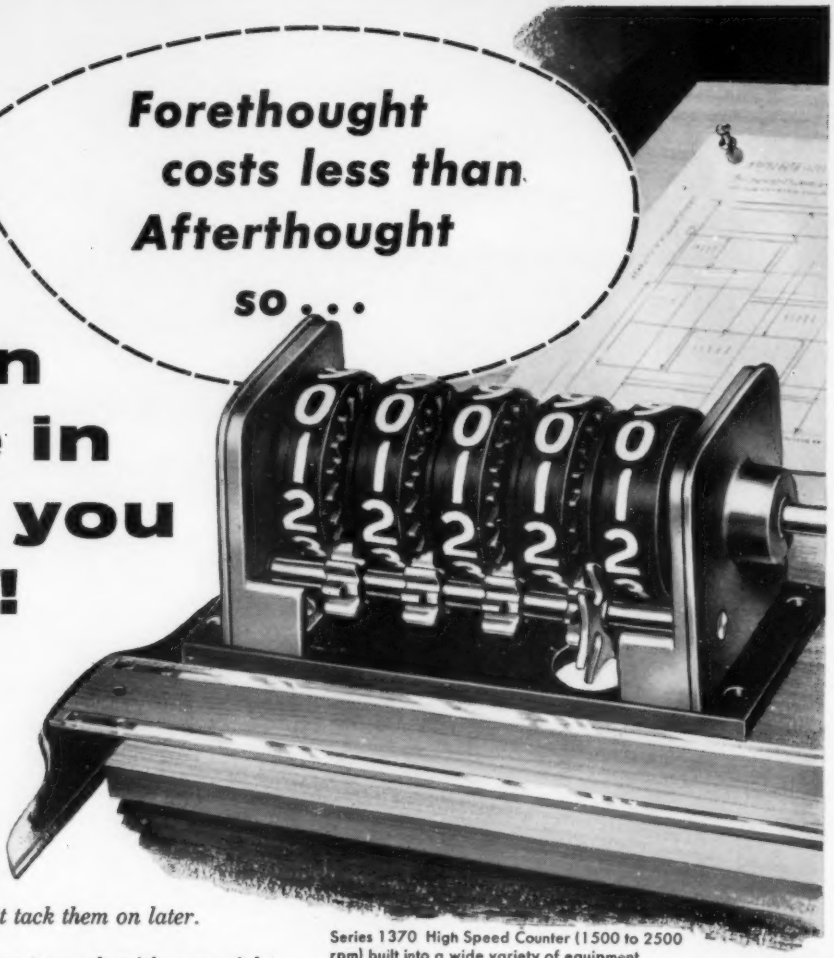
Final figures for 1957 radio and television sales by member companies showed radio holding its own and television down about 23% on 1956. Distributor sales to dealers of all types of radio receivers were 577,930 units (1956 — 577,205). Corresponding figures for television receivers were: 1957 — 470,823; 1956 — 612,871.

The 3,000,000th television set made in Canada was sold during January.

New CRTPB telephone number is Toronto WAlnut 3-4543.

Forethought costs less than Afterthought so . . .

Design These in When you Begin!



If you need mechanical or electrical counters in any of your new products, here's a word to the cost-wise designer: *Design them in, when you begin . . . don't tack them on later.*

Series 1370 High Speed Counter (1500 to 2500 rpm) built into a wide variety of equipment.

For if you'll give us a chance to work with you, right from the beginning, chances are we can save you time and money by adapting or modifying a *standard* Veeder-Root Counter to your needs . . where you might get into a costly special job if you went about it alone. What's more, you save time in your engineering, purchasing and assembly departments.

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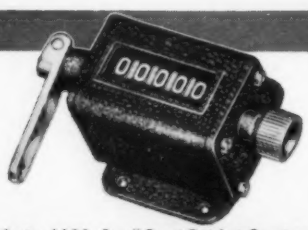

Series 1122 Small Reset Ratchet Counter.

Special Longitude Counter, one of many made for aircraft navigational equipment.

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Miniature recorders can be used with many types of input

There is a definite trend toward the use of transistors in the new process recorders now being prepared for the market. This will reduce the physical size and power requirements, as well as making the instruments more versatile.

The new designs were discussed by two engineers from Philips of Eindhoven during a recent visit to Canada. **W. Troost** and **F. L. Merjenberg** addressed a joint meeting of the Toronto branches of the Chemical Institute of Canada and the Instrument Society of America.

One feature of the new Philips recorders will be the use of a standardized instrument with wide selection of input amplifiers. This can adapt the instrument to many types of input by changing the amplifier and the transducer.

Troost and Merjenberg

Engineers move up at RCA

A native Calgarian, **Russel J. Good,** now manages the defense systems division engineering at RCA Victor Co. Ltd., Montreal. This division was recently created to handle the engineering activities associated with the electronic system for the CF-105.

Mr. Good graduated from the University of British Columbia in 1949 with a B.Sc. in engineering physics. This was followed with an M.Sc. from Toronto. He has been with the company since 1950, engaged in design, development and production engineering on various military electronic programs.

R. J. Norton has rejoined RCA as manager of special accounts. He will be responsible for sales to all government commercial accounts and is also product manager for aviation equipment. In 1950 he graduated from McGill with honors in engineering physics.

Canadian Admiral promotes four men

Promotions have been made within the Canadian Admiral Corp., Ltd., to fill four senior positions. As Product Manager, Television and Radio, **Wally Johnston** will cover TV, radio, hi-fi, phonos and related products. **Keith Comly,** Product Manager, Appliances, will cover refrigerators, ranges, home freezers, air conditioners, automatic dishwashers and dehumidifiers. They will both be responsible for the development of marketing programs, advertising and sales promotion objectives, market research and analysis for their respective product lines.

New manager of the Toronto factory sales branch is **Andy Hause,** formerly Ontario regional manager. **Tom Kelly,** former manager of the London sales branch, has taken over as manager of the Ottawa factory sales branch.

McRae takes top post in CGE

I. F. McRae has been elected chairman of the board of directors of Canadian General Electric, succeeding **H. M. Turner.** He will also retain his position as general manager of the Civilian Atomic Energy Department.

Mr. McRae, born in Vancouver, joined CGE in 1925 and became manager of Peterborough works in 1941. He was elected a vice-president in 1952.

New appointments have also been made within the Wholesale Department. **B. W. Donaldson,** former sales manager of appliances in Toronto, is now manager of the Mid-West District with offices in Winnipeg. **A. M. Hurley** has moved to Calgary as manager for the Alberta District. He was manager of apparatus and supplies sales in Montreal.

Caton

Brant

Expansion of electronics brings D.O.T. changes

Continued rapid advances in the field of telecommunications, including radio and electronic aids, have made it necessary to provide for better coordination between the branches of the Department of Transport. The man chosen to do this is **C. Mornington Brant,** 49, in the newly created position of Chief of Technical Coordination. Succeeding him as Controller of Radio Regulations is **W. A. Caton,** former Chief of Inspections and Examinations.

Mr. Brant was born in Holbeach, England, and received his first radio training in the RAF training school at Winchester. In 1937, when an employee of the Civil Aviation Branch of the British Air Ministry, he was sent to Newfoundland to supervise the construction of radio communications to set the stage for trans-Atlantic commercial aviation.

Mr. Caton will now be responsible for the enforcement of the Radio Act and Regulations, and the Radio Section of the Canada Shipping Act. Under him will also come the operation of Ionosphere and Monitoring Stations, development of technical standards for equipment and also research and development in radio interference operations.

Dr. Thomas H. Hogg, P.Eng., dies at age 73

One of Canada's outstanding engineers, Dr. Hogg, died suddenly in Toronto, February 24.

Born in Chippawa, Ontario, Dr. Hogg was the first employee of Ontario Hydro to rise to its chairmanship. He held this position from 1937 until 1947. Last month he was awarded the Professional Engineers Medal by A.P.E.O.

Writer moves into technical sales

The technical writing industry is losing one of its most experienced writers. **Herb Parkes** has joined the Electrodata Division of Burroughs as sales technical representative in the Toronto area.

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Hyfen ends the need for time consuming solder operations — and the high rejection rate inherent with solder. Pins and sockets are speedily crimped on wire ends by automatic installation tooling — or where more convenient, by bench or hand tools. Dies control and provide a uniform depth of indent which can be inspected by depth micrometer assuring absolute unvarying reliability. Crimping may be done before or after harness is in place.

Hyfen meets or exceeds MIL specifications for voltage drop, dielectric strength, contact engaging force, and contact retention force. It provides high corrosion resistance since there are no fluxes or dissimilar metals involved. Floating contacts in both plug and receptacle make for uniform mating and disconnecting force by the alignment flexibility provided.

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CAE awarded $2 million defense contract

Almost half the total dollar value of the unclassified contracts awarded by the Department of Defence Production during the first half of January consisted of a $2,048,435 contract placed with Canadian Aviation Electronics Limited. CAE will manufacture general type flight and instrument trainers for the RCAF's twin reciprocating engine aircraft.

The Montreal firm have also announced that they will design, develop and manufacture an operational flight trainer for Canadair's giant CL-28 Argus submarine hunter, and make a design study for a tactical procedure trainer related to the CL-28's complex radar and weapons system.

CAE have previously produced flight simulators for the RCAF's CF-100 all-weather interceptor. Recently it completed manufacture of the first commercial simulator to be built in Canada. This was the DC-6B passenger airliner simulator ordered by Canadian Pacific Airlines.

Other defense contracts

Among other unclassified contracts recently placed by DDP are the following: Bach-Simpson Ltd., London, Ont., spares for aircraft instruments, $41,522; Beaconing Optical and Precision Materials Co. Ltd., Montreal, fire control equipment, $31,215; Canadian General Electric Co. Ltd., Toronto, electronic equipment, $78,243; Canadian Marconi Co., Montreal, radio transmitting equipment, $52,144; Canadian Marconi Co., Toronto, electronic tubes, $444,075; Cossor (Canada) Ltd., Halifax, N.S., electronic equipment, $55,-264; Radio Communications Equipment and Engineering Ltd., Lachine, Que., electronic equipment, $22,403; Computing Devices of Canada Ltd., Ottawa, technical publications, $247,-183; Sperry Gyroscope Co. of Canada Ltd., Montreal, modification of gyro compass system, $24,455.

Toronto technical writers form STWE chapter

Technical writers from the Toronto area have taken preliminary steps to form a local chapter of the Society of Technical Writers and Editors. This will be the third Canadian chapter—others are in Montreal and Ottawa—of the North American organization, which now has a total membership nearing 2,500. A temporary slate of officers was elected last month and further meetings will be called during March to launch the Toronto chapter and plan for future activities.

The aims of SWTE are to raise the standards of technical writing through the media of training courses and self-examination. The group is also striving to gain due recognition for their contribution to the world of science.

"Professional engineers on threshold of new era"

There are 16,450 professional engineers now registered in Ontario, an increase of 1,352 as of a year ago, it was announced at the annual meeting of the Association of Professional Engineers of Ontario, held in Toronto on February 1.

In a forecast of 1958, C. T. Carson, P.Eng., of Windsor, president-elect of the Association predicted that the engineering profession in Canada was on the threshold of a new era in which professional recognition and professional status would be universally achieved.

Dr. A. Conrad Posz, assistant professor of communication skills at Michigan State University spoke at the annual luncheon meeting on the subject "Why do we behave like people?" Over 1,000 Association members and guests attended.

News in brief

CSA approval has been given to all Tork time switches, distributed by Dominion Electric Mfg. Co. Ltd., Toronto.

New Canadian representative for the lacing tapes manufactured by the electronics division of Gudebrod Bros. Silk Co., New York, N.Y., is E. E. Whittaker of Arnprior, Ont.

Mr. Whittaker's representation of Dynamic Gear Co., Amityville, N.Y., was also announced recently.

Bayly Engineering Ltd., Ajax, Ont., have added The Arnold Engineering Co., Marengo, Ill., to their list of principals. Arnold produce a wide range of magnetic materials.

Canadian Electronics Ltd. of Edmonton have moved into their new 16,000-sq.-ft. office, showroom and warehouse building, 109 St. at 107 Ave. Official opening by Alberta Premier Manning was held on January 21.

A. C. Wickman Ltd., Toronto, has assumed the agency of Edin Company Inc., Worcester, Mass. The new line consists of oscillographs and amplifiers for industry and the medical profession.

Zenith Radio Corporation of Canada Ltd. have formed a radio-TV-electronics division, with Lloyd B. Kiely as general manager.

Changes of address are announced by two firms in the technical writing and illustrating field. Cushing & Nevell Ltd. are now at 181 Eglinton Ave. E., Toronto 12. The technical publications division of Electronics Associates Ltd. has moved to 105 Willowdale Ave., Willowdale, Ont.

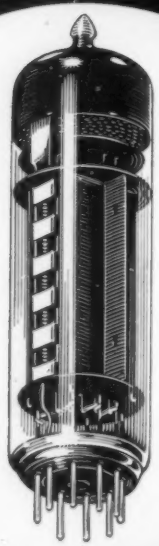
Results of the Professional Engineers' Salary Survey, compiled by the APEO during 1957, attracted wide interest during the annual meeting. T. C. Keefer, P.Eng., Toronto, Association Field Secretary is shown here pointing out the details to (left to right): Y. H. Williamson, P.Eng., Panmour, Ont.; Fred Bainbridge, P. Eng., Chalk River, Ont.; W. L. Wardrop, P. Eng., Winnipeg, Man.

The Rogers 6360 twin tetrode. is a Special Quality* miniature transmitting tube designed to give reliable, efficient and long life performance at V.H.F. up to 225 Mc/s at maximum ratings.

Typical plate output power is 14.0 watts at 200 Mc/s with a plate supply voltage of only 300 volts. As a tripler with an output of 175 Mc/s, 5.5 watts is obtained with a plate supply voltage of 300 volts.

The 6360 is particularly suitable for push-pull operation in either fixed or mobile transmitters and may also be used as an amplifier, oscillator, multiplier, modulator or audio amplifier. In new equipment or for replacement purposes, this Special Quality tube provides high output at very low initial cost.

**Rogers Special Quality tubes are finding more and more applications in all types of professional equipment. The greater reliability and lower maintenance cost of the apparatus in which they are used more than compensates for the higher initial cost.*



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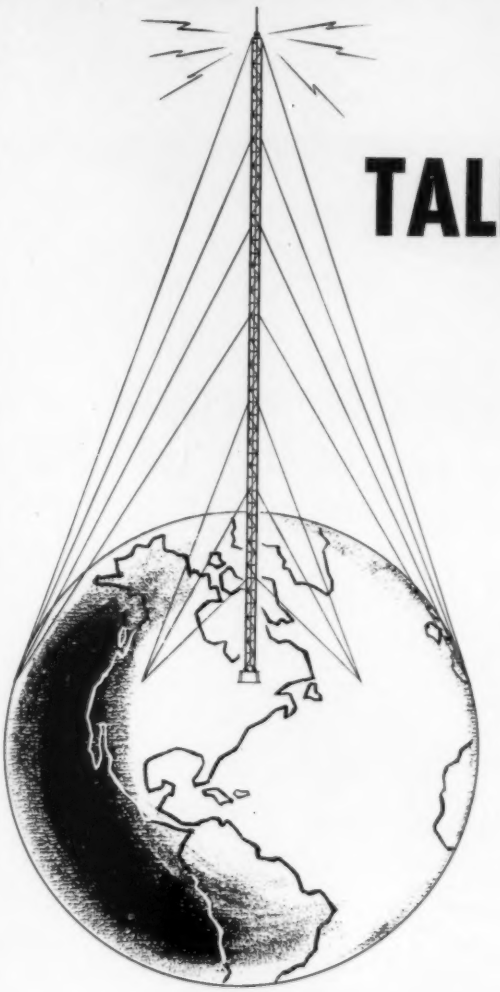

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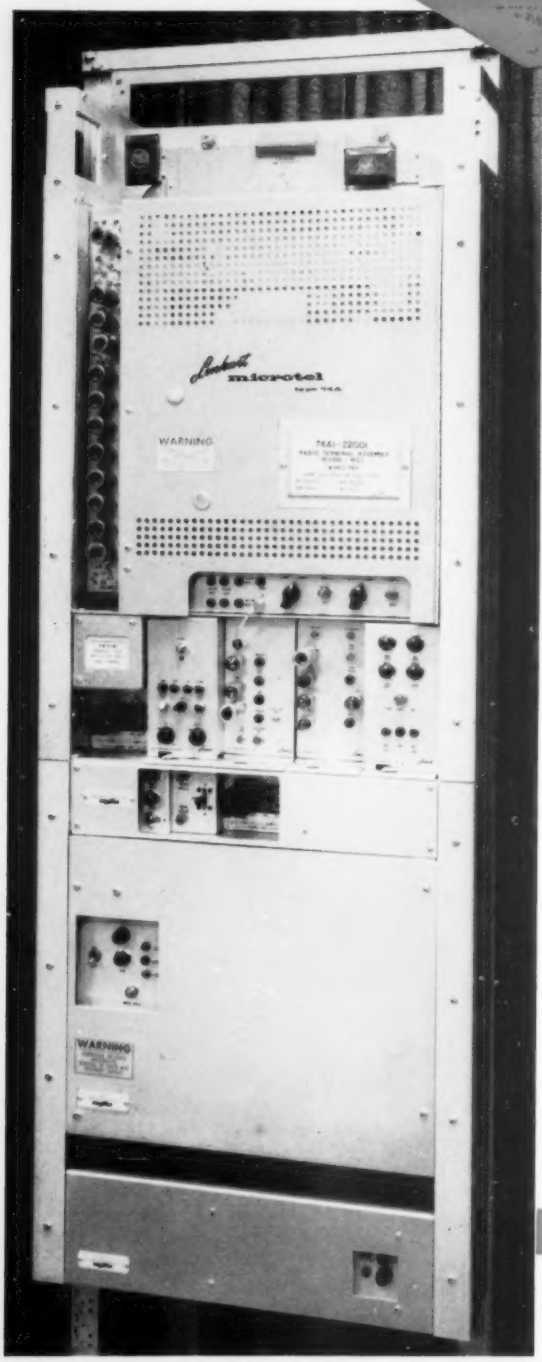

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Microtel is equally satisfactory whether the need is for only a few circuits or for a high density network requiring as many as 720 voice channels. It is available from Automatic Electric as a complete package—engineered, supplied and installed—on one order.

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- **ECONOMICAL EXPANSION**—With Lenkurt 45BX carrier, a single terminal can accommodate up to 240 channels; with r-f circulator, 2, 3 or 4 terminals can be added to same antenna system.
- **REPEATERS**—Back-to-back terminal equipment permits dropping and reinserting of channel groups; automatic switching permits unattended operation.

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GENERAL TELEPHONE SYSTEM

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CANADIAN
ELECTRONICS
ENGINEERING

Strike while the iron is hot

The Canadian Conference on Education, held in Ottawa just two weeks ago, heard experts in many fields propound their ideas and plans for the improvement of all areas of our educational system.

In what we have come to call the "atomic age," which is now rapidly becoming the "space age," scientific educators are finding themselves faced with a dual challenge. There is above all the continual reaffirmation that "the more we learn, the more we realize there is yet to learn." To this has been added the challenge of scientific and educational competition between East and West, illustrated by the race to get satellites into orbit.

One of the most important speeches at the Conference concerning scientific and technical education was that of Mr. H. H. Kerr, Principal of Ryerson Institute of Technology in Toronto. Speaking to the workshop on the financing of education he quoted Dr. H. L. Bevis, Chairman of The President's Committee on Scientists and Engineers as having said recently:

"The President's Committee recognized the shortage of technicians at its very first meeting. The Committee, from information available to it, concluded that the shortage of technicians in many areas is probably even more severe than the shortage of scientists and engineers. The Committee was alarmed at the fact that our nation in its technical institutes and junior colleges produced but one technician for every two or three engineers. I have no magic number of what this ratio should be, but available information in our country and our industrialized friendly nations leads me to believe that the ratio should be reversed. I do not mean that fewer scientists and engineers should be produced: rather, many more well-trained technicians are needed today and will be needed in the future. In one sense, this means that the problems faced by presidents of technical institutes and junior colleges are double or triple those faced by presidents of colleges and universities."

We believe that this puts very clearly the situation which Mr. Kerr rightly claims also exists in Canada. We also hope that action will soon be taken to remedy matters and feel that two points made by Mr. Kerr show clearly what can be done: "It is no secret that those who are directly concerned with the financing of the (technical) institutes believe that the Federal Government should give some financial aid. In fact, it is doubtful if Canada will witness much of an expansion in this field until such assistance is forthcoming.

"Industry, too, should participate more actively in the financing of the institutes by supplying larger sums for scholarships and bursaries and for equipment. The type of training given is geared to bring direct benefit to business and industry, and the funds thus provided should bear a more direct relationship to the considerable benefits they receive."

Let's strike while the iron is hot!

THE EDITOR

A comprehensive instruction book, well written and illustrated, is an indispensable part of modern electronic equipment

Planning cuts instruction book costs

IAN R. DUTTON, ASSOCIATE EDITOR

Technical writing, both for reports and instruction books, has become an important part of engineering. There are many facets of the subject, three of which will be presented in this and future issues. The present story deals with problems that can arise when a manufacturer issues poor instructions with his equipment. It then shows ways in which good books can be prepared at minimum cost, and ends up with sample cost figures plus methods for cost estimating.

The technical writing business in Canada has grown from relative obscurity in 1950 to a position of importance in the electronics industry today. There are now at least three companies engaged exclusively in the preparation of instruction books, with another half dozen having departments specializing in this work. Besides this, many of the manufacturers have technical writers on their staffs to handle all, or part of their writing projects.

However, despite these significant improvements, many Canadian manufacturers still fail to provide adequate instructions for the installation, operation, maintenance and repair of their equipment.

Why? On the surface this may look like an honest attempt to reduce cost. In reality it indicates lack of good planning and failure to realize that poor instructions can damage sales.

A customer can get along without the use of an instruction book but it's going to cost him a great deal of extra time learning how to operate and service his new equipment. He may also damage the equipment, leading to costly repairs. If he encounters unjustified expense you may be sure his comments will not enhance the manufacturer's reputation. And while his lost time expenses may be somewhat hidden, his repair bills will likely wind up as a warranty service charge against the manufacturer.

There are a few outstanding success stories of recent years. One that will be familiar to many readers is the rapid increase in the sale of Heathkits. No doubt the products themselves, and the prices have been major factors in building sales, but the instruction books must be given due credit for their part. These instructions have been written in such a way that the average customer can follow them without difficulty. If this were not the case, word would soon spread around and sales would drop off.

Why then do so many of the other manufacturers fail to issue good instruction books with their equipment?

To understand the subject it is first necessary to have a clear understanding of the words "technical instruction book."

An instruction book is a medium by which information is transferred from the designer to the customer.

In this case the word customer is used in a broad sense to describe anyone called upon to install, operate or repair the equipment.

A major factor in the problem is that manufacturers fail to think of an instruction book in terms of the basic

definition. Instead, they think of the individual details and become confused. Or they may not even think about a book until the day their customer phones back with a rather irate tone to his voice.

The customary excuse preferred for poor books is high cost—and this is probably done with all sincerity on the part of the manufacturer. But like any other part of the operation, improvement comes only with intelligent planning and application. Besides, customers are not interested in buying excuses.

The time to start thinking about a new writing project is during the initial planning and cost estimating for the over-all project. At that time the decision must be taken as to the scope of the book, just as is done with the equipment. From that point on, the cost can be controlled and kept to a minimum if the plans are carried out by all concerned.

Design engineer is key source

Information must be extracted from the design engineer before it can be presented to the customer. This is the information he has acquired during the weeks or months spent with the project. Research and development time is expensive and it is the engineer's duty to make all his acquired knowledge available for full use within the company. It is not enough to say that his only objective is to produce a set of drawings and specifications from which the equipment can be built.

The chief reason why engineers are loath to help the technical writers is because they are too busy. It is, then, the responsibility of management to establish realistic work schedules and stop loading down their engineers with petty, time-consuming chores.

To conserve the engineers' time several short cuts and combined operations may be possible. For instance, many of the reports normally used by companies to chart the progress of work may be a source of information for the technical writer. Or the writer may be able to work with the design engineer during certain periods to get the experience and information directly, and with the same outlook as the customer may have — that is, from a cold start. But there will still be information acquired by the engineer during his work that should be at the disposal of the writer. To get this, some companies have been using dictating machines and tape recorders with good success. It is faster than writing and tends to draw out more useful information after the engineer gets started. Without having to concentrate on sentence structure or other mechanics, he loosens up and gives the writer what he needs.

The more technical knowledge the writer has the less time that will be required from the design engineer. Some writers could, in fact, prepare a full technical story with no assistance other than the schematic, but there is little point to it. They would essentially have to go through the same steps as did the designer to learn all the details.

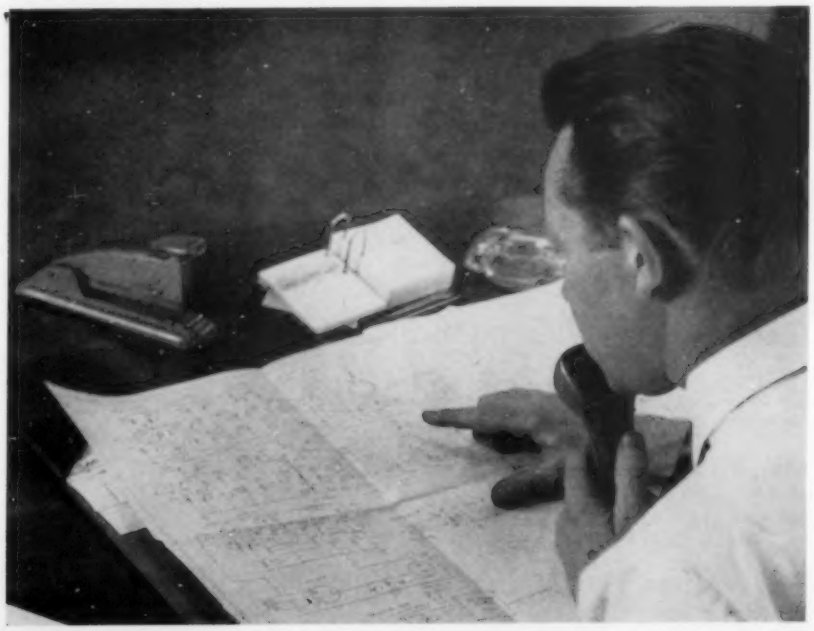
The objective then, is to employ writers who can talk and work with the design engineers to get the basic information with minimum interruption of the designer's schedule. Such writers command prevailing engineering salaries, but they can turn out better work at lower total cost than can non-technical or inexperienced writers.

The other major area for cost control is the scope of the instruction book. To be effective, the book must contain sufficient information to allow the customer to use his equipment with minimum familiarization time and minimum risk of damaging the equipment during this period. If the book falls below this standard it fails to be completely effective. If it contains more information than needed, it becomes an expensive luxury, and perhaps a confusing one at that.

It may, however, be designed to fill a dual role such as instructing and selling. This can be a good thing. By adding slightly to the content of the book and tidying it up with good paper stock, a good cover and neat layout, it can easily become a first class selling aid. But these are decisions that must be made during the initial planning if the cost is to be recognized and maintained at a reasonable level.

Subcontracting can save money

There is a peculiar psychological reaction in the minds of many manufacturers regarding the subcontracting of instruction book writing. In many cases, their first reaction is one of skepticism. How can a total stranger possibly write instructions about equipment he has never before seen? But surely this is precisely the same situation with a



Information on new equipment or design projects must come from the engineer who has done the work. Part of this will exist in notes and progress reports, but further information likely will be needed. Time can be saved through the use of recording machines

writer from within the manufacturing company. He seldom sees the equipment until it is well under way.

At this point the manufacturer will probably argue that the design engineer is really the only man who can prepare the instructions. This is not true. In fact it is a poor policy to have the design engineer do the finished writing, even though he must provide the initial information. When he has reached the stage where he can devote time to the final writing, the writing, in many cases, should be completed and the book printed. Furthermore, the designer "lives" with his project so long that he cannot back away to take a fresh look at it as the customer must do.

Another stumbling block comes with military handbooks. Here the writing specifications are very rigid and the writer must be thoroughly familiar with them. Few design engineers can devote sufficient time to gain and maintain this knowledge of the changing requirements.

So the idea of subcontracting is quite logical after all. In fact, it can become an economical procedure if handled properly. The alert writing companies are in constant liaison with the armed forces to keep abreast of the changing requirements and specifications for handbooks. This can save a manufacturer many hours and dollars, as well as avoiding embarrassing delays and problems.

Writing companies also employ writers who are competent in both the fields of electronics and writing. The hourly rate may be slightly higher than the manufacturer would pay for his own staff, but the total cost is generally lower because the subcontractor makes better use of his time. This can also result in less time being required from the design engineer.

Military handbooks

So far, little has been said about the handbook requirement of the armed forces. It can safely be said, however, that the armed forces are responsible for bringing the technical instruction book industry up to its present high standard of performance. They needed good books and were prepared to spend the necessary money to establish specifications for guidance of the writers.

This was money well spent. After all, consider the case of an army technician at one of the isolated radar sites along the DEW line. When trouble develops in his equipment, he can't pick up the phone to ask the manufacturer what he should do about it. He must be self-reliant, and therefore, needs instruction books that are complete in every detail.

This, of course, means that military books are rather expensive as compared with some of the commercial manuals. But it must be emphasized that the cost is justified and results in lower maintenance costs over the lifetime of the equipment.

The total costs are steadily rising, even though the value received is also improving. Probably the largest single reason is the increasing complexity of the equipment. The large radar installations of World War II look rather insignificant besides today's monsters. And the trend could continue. In the United States, the handbooks for one large type radar equipment about eight years ago cost approximately $1,000,000. Now it is reputed that the instruction books for one of the larger missiles are going to cost about $8,000,000.

The second reason for increased cost on military handbooks stems from the upgrading of the contents. Experience has led to the rejection of certain items in the books, but the inclusion of more useful information. This increases the value of the books but at increased cost.

With the armed forces' increasing difficulty in recruiting experienced technicians, instruction books of the present day must be written to a lower starting level, at greater cost. And the men who do this writing now command a better salary than they did six to ten years ago. This reflects the increased recognition being given the writing profession, but all the cost increase has not gone to the books. The writing companies and the technical writers have improved their standards noticeably as a group. This increased efficiency means that they can balance a major part of their rising income with better operating techniques.

What do instruction books cost?

Cost figures vary widely depending upon the nature of the equipment, customer, size of book, amount of information already available, etc. Several rough yard sticks exist for estimating the approximate cost of a writing project, but the only safe method is to consult an experienced writer presently in the business and familiar with current cost figures.

One company estimates that where the cost of designing and building the first prototype equipment runs between $10,000 and $1,000,000 the instruction book cost will add another 10-15%.

Another rough measure is $125 per page for any book of 25 pages or more. This applies to the gathering of information, liaison, writing, artwork, and preparation of reproducible copy. It does not include the cost of printing since that varies so widely depending upon the quantity involved.

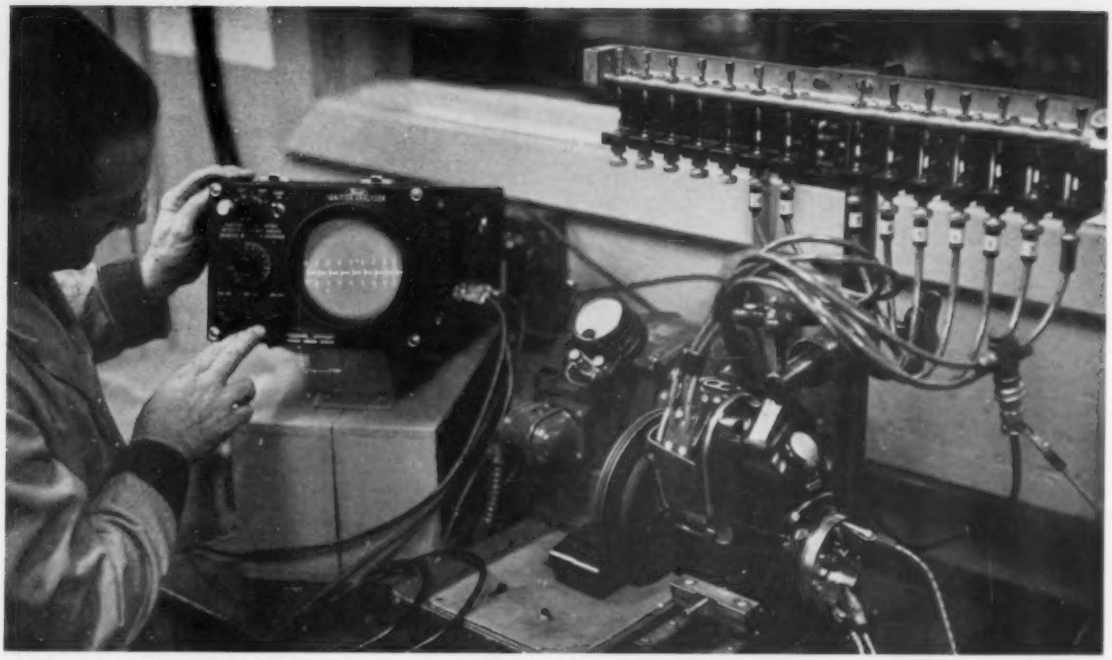
During a major writing project about eight years ago an American company found that writing time (including gathering information, checking, writing and editing) ran at eight hours per page. Schematics cost $150 each and photographs $35 each including the retouching. Other artwork averaged 12 hours per illustration.

Still another figure from a manufacturer placed the cost of his instruction book group between 2% and 4% of his over-all budget. This was for a department working on military equipment only.

It must be stressed that these cost figures will vary widely from one project to another and from one company to another. A safe procedure for cost estimating is to try to get an existing instruction book on equipment that is comparable to the equipment being planned. Using this as a starting point, the technical writing supervisor in the company, or a subcontractor can provide cost figures. But the important thing is for management to recognize that decent instruction books are needed, and to plan the writing project as an integral part of the over-all equipment designing and manufacturing operation. Only in this way can the manufacturer satisfy the needs of his customers at a realistic cost figure. END

REFERENCES:

1. *Barzun, J. and Graff, H. F., "The Modern Researcher," Harcourt, Brace and Co., 1957.*
2. *Bodner, F., "The Loom of Language," W. W. Norton, 1944.*
3. *Flesch, R., "The Art of Plain Talk," Harper and Brothers, 1946.*
4. *Gowers, Sir Ernest, "Plain Words," Her Majesty's Stationery Office, London.*
5. *Kapp, Reginald O., "The Presentation of Technical Information," Constable, 1948.*
6. *Quiller-Couch, Sir Arthur, "On The Act of Writing," G. P. Putnam's Sons, 1943.*
7. *"Roget's International Thesaurus," Thomas Y. Crowell, 1946.*
8. *Souther, James W., "Technical Report Writing," John Wiley & Sons, Inc., 1957.*



Bench testing of aircraft engine magneto using ignition analyser—spark plug waveforms are displayed on cro screen

Ignition analyser eases aircraft engine maintenance

L. S. EGGLETON*

The difficulty of locating faults in complex ignition systems brought about the necessity for an ignition analyser. The unit which has been developed not only locates faults but also serves to prevent them occurring. Typical waveforms seen on the analyser cro screen and alternative synchronization methods are described. Reference is also made to a device used for measuring the relative "health" of a particular ignition system.

High on the list of irksome tasks confronting maintenance crews of piston-engined aircraft is the location of ignition trouble.

Unlike automobile engines, aircraft engines customarily have two spark plugs to fire each cylinder, moreover each plug is operated by an entirely separate ignition system, consisting of a magneto and associated components. The purpose of this duplication is twofold. First, the dual ignition systems provide an insurance against complete stoppage of the engine due to ignition failure in flight; second, the cylinders of aircraft engines are of large capacity and the simultaneous firing of the two plugs ensures smooth, even burning of the fuel mixture.

Passengers in aircraft may sometimes wonder exactly what takes place in the cockpit during that seemingly interminable running-up of engines at the end of the runway. Among numerous other checks, the pilot is testing the relative efficiency of the magneto and other components of the dual ignition systems on each of his engines.

To do this he opens the throttles to a specified speed, which he observes on his revolution counter, with both magnetos in circuit. He then switches off in turn, first one magneto, then the other, and notices how much (if at all) the speed of the engine reduces. If the speed reduces beyond a given fraction of the total rpm, the ignition system is considered unsafe for flying. This condition is known as excessive "mag. drop" and the aircraft returns to the hangar.

*Aviation Electric Limited, Montreal.

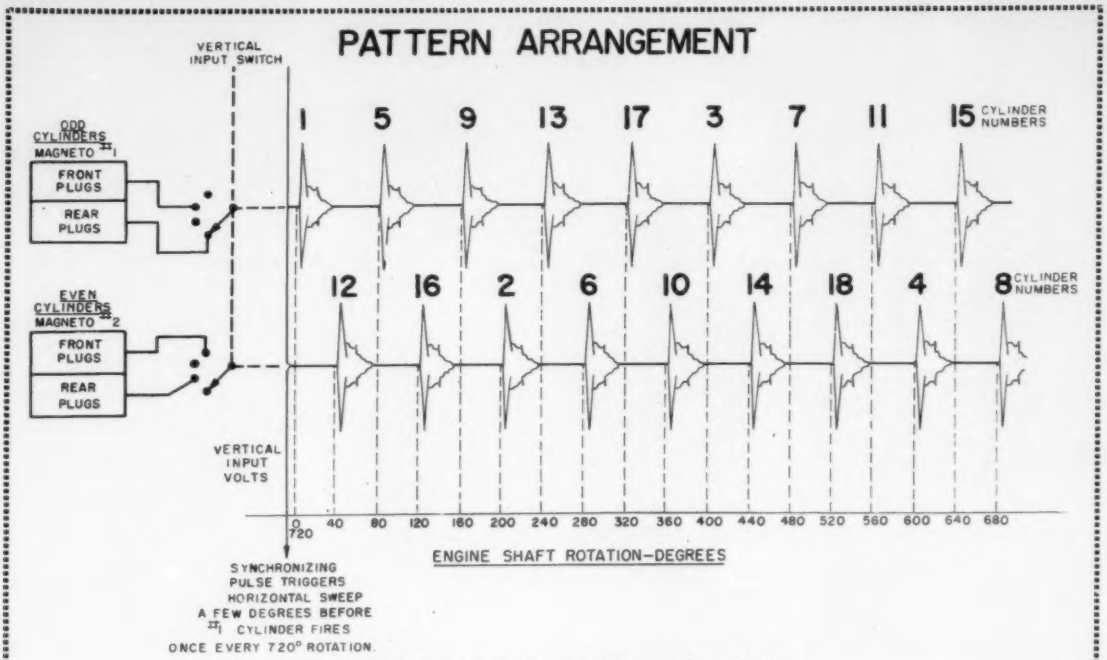

PATTERN ARRANGEMENT
VERTICAL INPUT SWITCH
ODD CYLINDERS MAGNETO #1
FRONT PLUGS
REAR PLUGS
EVEN CYLINDERS MAGNETO #2
FRONT PLUGS
REAR PLUGS
1 5 9 13 17 3 7 11 15 CYLINDER NUMBERS
12 16 2 6 10 14 18 4 8 CYLINDER NUMBERS
VERTICAL INPUT VOLTS
0 720 40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640 680
ENGINE SHAFT ROTATION—DEGREES
SYNCHRONIZING PULSE TRIGGERS HORIZONTAL SWEEP A FEW DEGREES BEFORE #1 CYLINDER FIRES ONCE EVERY 720° ROTATION.

Fig. 1. Typical arrangement of ignition analyser displays

The maintenance crew, filled with gloom at this event, is now faced with the task of determining which of the many spark plugs or ignition components is at fault. An average radial aircraft engine with two banks of cylinders would have 18 cylinders, each having two spark plugs — a total of 36 plugs to be taken out and replaced. With engines having four banks of cylinders the situation is correspondingly aggravated.

How much better if this time-consuming task could be shortened by pin-pointing the exact location of the trouble.

Continuous display

The Scintilla Division of Bendix Aviation Corporation has, in their Ignition Analyser, provided an effective, and continuous, display of the ignition system in operation. Installed either permanently or temporarily in the aircraft, the Ignition Analyser provides the ground or flight engineer with valuable data on the dynamic performance of his engines. An ignition fault can thus be diagnosed in flight, and ground crews can be alerted by radio to have the correct replacement component ready to install.

The basic indicating device is a cathode-ray oscilloscope with a relatively slow sweep speed of between 16.6 and 23.5 cps depending on engine speed. To assist in the elimination of the flicker inherent in slow sweep-speeds a long persistence tube such as the 5LP1-A is used. Initiation of the saw-tooth for the horizontal deflection is carried out by a trigger pulse from a sync. pulse generator.

Vertical deflection is provided by a signal pick-up in the primary (low tension) side of the magneto or ignition coil. The high tension spark, as it jumps the gap of the spark plug sets up a damped oscillation in the secondary of the coil, which is repeated in stepped-down version in the primary. The characteristic waveform of a correctly operating plug is easily recognizable and, moreover, each fault has been found to have an individual waveform which can be recorded and used to identify it when it appears.

These waveforms vary somewhat with each type of engine, but charts can easily be made and supplied to engine users.

Let us consider the case of a typical 18 cylinder, double bank, radial aircraft engine. In order to display the discharge of each spark plug in its proper relative position on the crt screen, the start of the horizontal sweep must be synchronized with the firing of one particular cylinder. All reciprocating engines have an individual firing order which is rarely consecutive as regards cylinder numbers. The result of this is that by synchronizing the crt sweep with No. 1 cylinder, the display will show the other cylinders firing in numerical order (for example, 1-12-5-16-9-2-13-6-17, etc.).

The horizontal sync. pulse is therefore generated by a cam-operated breaker driven at half engine speed, the output being essentially a square wave. This is applied to a differentiating circuit where the positive spike is used to generate the trigger pulse for the scope horizontal sweep. The negative spike is rejected.

On an aircraft engine with two banks of cylinders, each bank of nine cylinders has its own distributor, offset 40 deg. of rotation from the other. By making a pick-up connection for vertical deflection at each magneto primary lead all the cylinders fired by the related circuit can be displayed on one complete sweep. By switching vertical inputs, all the remaining cylinders can be displayed in turn on another sweep. Because the same horizontal sync. pulse generated by No. 1 cylinder is used, the first cylinder display will show a 40 deg. phase lag from the second.

Eighteen of the 36 spark plug waveforms have now been displayed. The other 18 displays are produced by the second independent magneto and are also switched into the vertical amplifier input. The sketch in fig. 1 shows a typical combination of displays on an 18 cylinder radial engine.

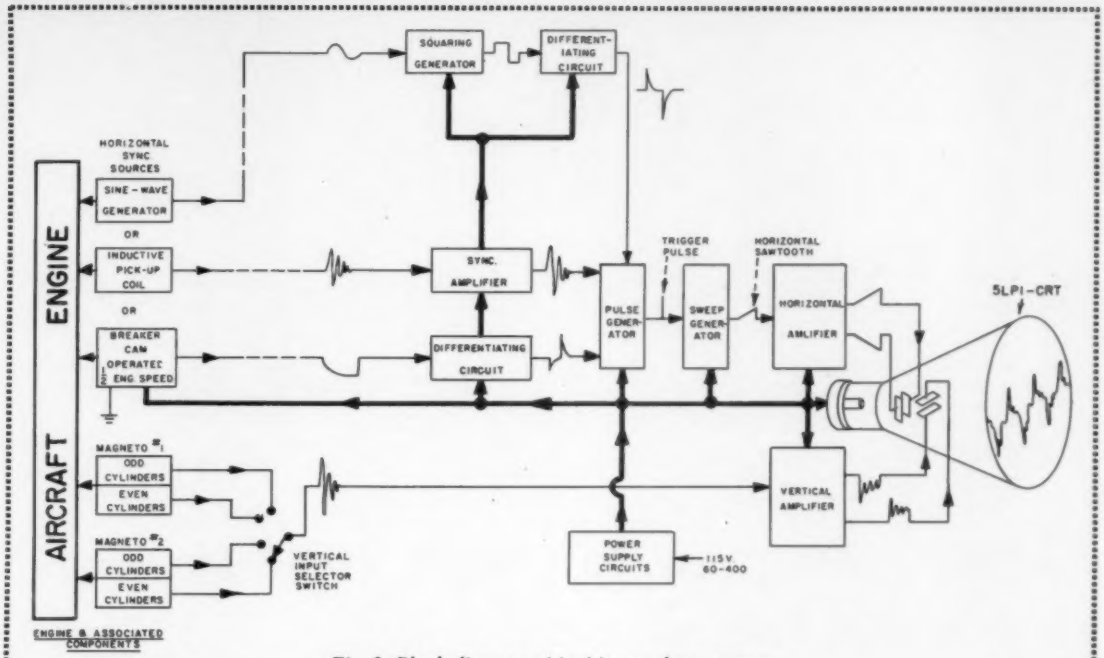


Fig. 2. Block diagram of ignition analyser system

Alternative methods

For various reasons, it is not always possible or desirable to use the contact breaker as a means of obtaining a horizontal sync. pulse, but two alternative methods can be used.

In aircraft where a half-engine-speed drive shaft is fitted, a sine wave generator can be driven. The sine wave output is passed to a squaring generator, where it is amplified, clipped and converted to a square wave. This is then differentiated and the positive spike used to drive the horizontal trigger pulse generator, in the same way as for the contact breaker. In aircraft engines where a drive shaft is not fitted the second alternative of inductive pick-up can be used.

Fig. 2 shows the block schematic of the ignition analyser system. All three methods of horizontal sync. are shown, but only one of these is in use at a time.

The photograph shows a magneto undergoing bench testing in Aviation Electric's Accessory Overhaul Shop, coupled to an Ignition Analyser. Spark plugs are simulated by the adjustable spark gaps in the background. The inductive pick-up method of synchronizing is being used as can be seen by the pick-up coil (right centre) connected in series with the high-tension lead to No. 1 spark gap. The nine waveforms associated with the nine spark gaps can be seen on the screen of the oscilloscope. Note the different shape of these waveforms compared with that of an actual spark plug as sketched in figs. 1 and 3.

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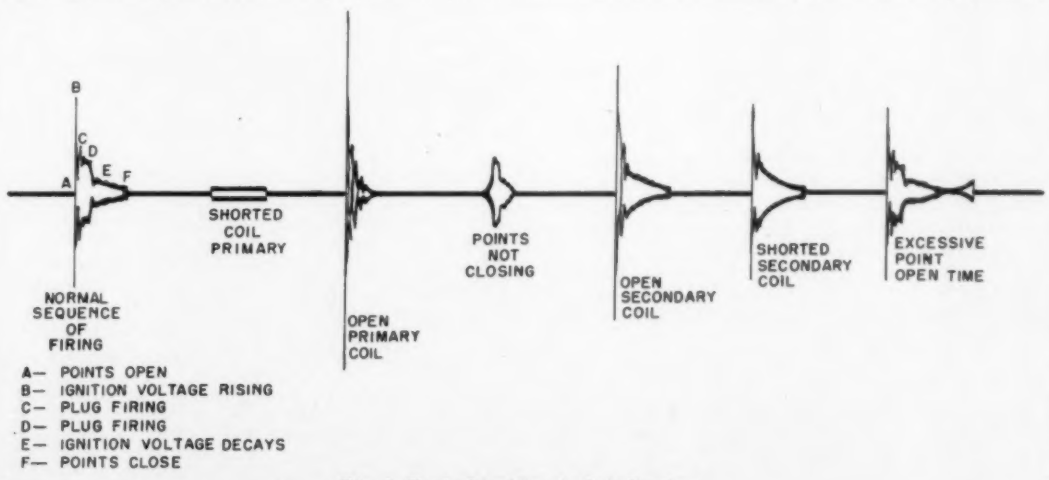


Fig. 3. Typical ignition fault indications

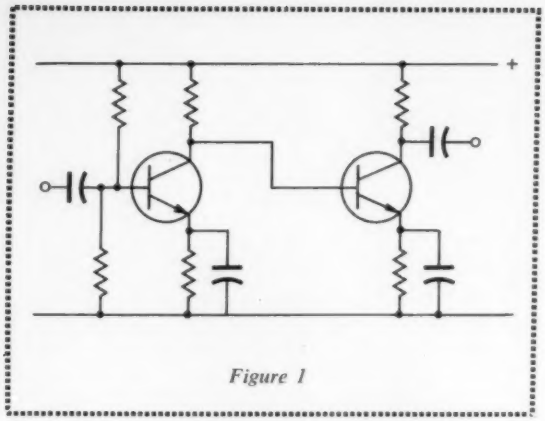


Figure 1

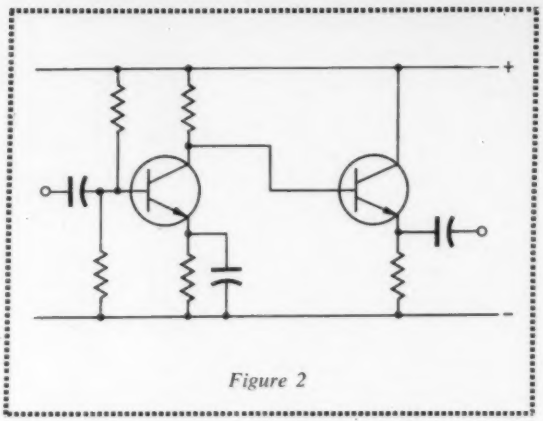


Figure 2

Circuit designed for high voltage gain from transistors

MAURICE PRICE, P.ENG.*

Following a similar vacuum tube circuit, a high voltage gain transistor circuit has been designed which overcomes many previous problems. Experiments suggest that the circuit offers considerably more advantages with transistors than with vacuum tubes. It has very high voltage gain, with economy of components, and a low impedance output.

When a high voltage gain is required, the transistor circuit designer is faced with some difficulty. In Fig. 1, a common emitter stage is cascaded with a second similar stage. The voltage gain from the first stage is severely limited by the low input impedance of the second. The high output impedance of the second stage is also a disadvantage in many cases, especially when the load is low. An improvement can be effected by feeding the first stage into a common collector second stage, as in Fig. 2. The voltage gain is limited in this case by the shunting effect of the collector feed resistor. This effect is extreme when a high collector current is required in the first stage. However, the circuit does offer low output impedance.

Improved Circuitry

A great improvement can be realized by using the circuit of Fig. 3. This has been obtained by taking a leaf from the vacuum tube circuit designer's handbook. The first stage is connected as a common emitter amplifier in the same way as in the previous two arrangements. The load on this stage now consists almost entirely of the high input impedance of the second stage, since all shunting effects have been minimized. The corresponding vacuum tube circuit uses a pentode feeding into a cathode follower with a similar interstage coupling network. Voltage gains of several thousand may be achieved with ease.

A closer examination of Fig. 3 shows that the only adverse shunting effects are:

(a) shunting of the load R_L by the feed resistance R_4

(b) shunting of the base-emitter impedance of Q_2 by R_5.

Both of these effects can be made negligible by a suitable choice of R_4 and R_5 even when the collector current requirements of Q_1 necessitate fairly low values of total series collector resistance.

The merits of the circuit lie in simplicity, elegance and considerable economy of components. Operating point stabilization is easily incorporated; one means is shown in Fig. 3, where the resistances R_1 and R_2 together with R_3 form a d-c feedback net for the first transistor. The second stage is stabilized by the action of R_4, R_5 and R_L.

Assuming that the shunting effects mentioned above are negligible, an approximation to the performance can be expressed as follows. The suffixes 1 and 2 refer to the first and second transistors respectively.

$$\text{Load on } Q_1 \doteq h_{fe2} R_L$$

$$\text{Voltage gain} = A_v \doteq \frac{h_{fe1}\, h_{fe2}\, R_L}{h_{ie1}} \quad \ldots\ldots (1)$$

$$\text{Power gain} = A_p \doteq \frac{A_v^2\, h_{ie1}}{R_L} \quad \ldots\ldots (2)$$

*Computing Devices of Canada Ltd., Ottawa

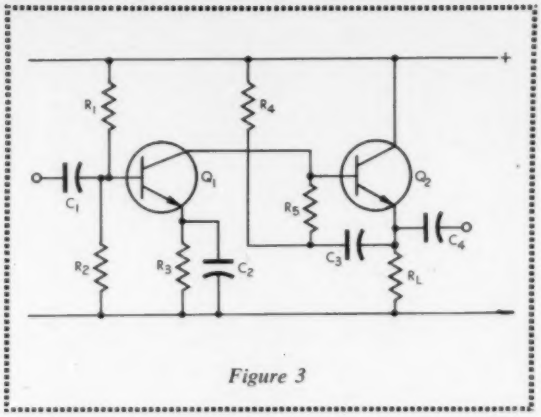


Figure 3

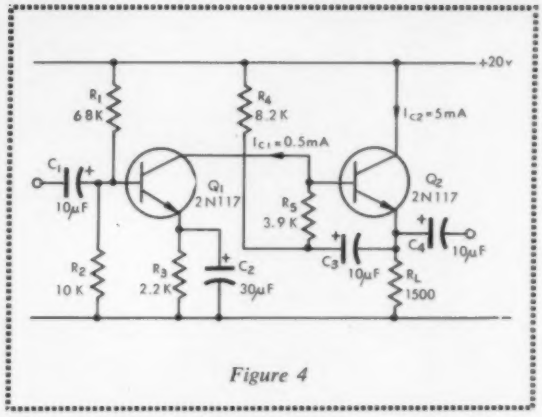


Figure 4

Example

Fig. 4 shows an example of the circuit using type 2N117 transistors. These have a power dissipation rating of 150 mW and are silicon npn units with a common emitter current gain h_{fe} in the region of 12.5. The circuit has been designed to operate in ambients of at least 80C. The collector current stability factors, assuming identical transistors with leakage I_{co}, are as follows:

$$S_1 = \frac{\partial I_{c1}}{\partial I_{co}} = 3.5$$

$$S_2 = \frac{\partial I_{c2}}{\partial I_{co}} = -9.0$$

The dissipation in the first stage is a few milliwatts, while that of the second stage is 75 mW.

The effective load consists of 1,500 ohms in parallel with 8,200 ohms, i.e. 1,270 ohms. The load on the first stage is then about 15,900 ohms. Since the input impedance of the first stage is approx. 600 ohms, the voltage gain works out to about 330, following equation (1). The over-all power gain into the 1,500 ohm load is then 46.4 db, which is an appreciable figure when the low current gains of the transistors are considered.

If the circuit of Fig. 2 had been used with the same resistor values, the voltage gain would have been about half the value obtained here. The circuit of Fig. 4 was constructed, and actual measurements at 400 cps gave the following results:

A_v = voltage gain = 350
Z_i = input impedance = 900 ohms
A_p = power gain = 73,500, corresponding to 48.7 db.

Conclusion

Very high voltage gains are possible in the circuit of Fig. 3 with economy of components. The experimental results given would have shown even more impressive improvements if transistors with high current gain had been used. The low output impedance of the circuit is a further advantage. This circuit seems to offer even greater advantage with transistors than with vacuum tubes. END.

Ignition analyser . . .

Continued from page 19

The efficiency of operation of any item of electronic equipment using a visual display will depend on the interpretation of the indications by the human operator. Recent cases of accidents due to misinterpretation of radar displays emphasize this in dramatic fashion. The same is true of the Ignition Analyser, and a person experienced in its use will be able to detect faults of a more subtle nature than one less familiar with its use. A fault display of this type is, however, more useful in detecting premonitory symptoms of failure in a component, while the easily recognizable displays denote existing defects. Fig. 3 shows some of the more obvious displays and their attendant faults.

Fault Prevention

The displays up to this point have been concerned with actual, or incipient faults. However, on the principle that prevention is better than cure, it would be very desirable to know something about the "goodness" of a perfectly functioning ignition system. This factor, which might be regarded as the equivalent of Q in a tuned circuit, can be gauged by a very simple but effective device built into Scintilla Ignition Analysers. Fig. 4 shows a variable resistor R shunted across the primary winding of the magneto. When an analysis of the "Q" of an ignition

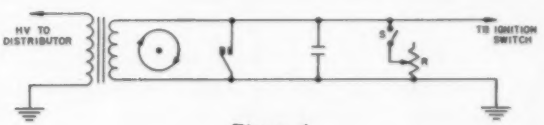


Figure 4

system is desired, switch S is closed, placing R in parallel with the magneto primary winding.

When the slider of the resistor R is at maximum ohms, only a small part of the current normally passing through the magneto is diverted through R. As the resistance of R is decreased, however, the amount of current in the primary winding of the magneto will decrease until the spark plugs cease firing. The point at which this occurs is an excellent measure of the condition of the ignition components. In practice, a dial calibrated in arbitrary numbers is attached in the slider of R. Let us assume that the maximum resistance of R corresponds to the figure 50. The dial is then turned until the "plug-firing" pip (C on fig. 3) disappears, and the reading between zero and 50 then noted. The assumption can now be made that the lower the dial reading, the greater the efficiency of the system.

This lower limit will vary greatly with various types of ignition systems; but, once established, provides a reference point for measuring the "Q" of that system.

Ignition Analysers thus provide a versatile instrument, not only for the detection of existing faults, but also, more economically, for their prevention. END

Three-channel tape recorder monitors test flight talks

*P. A. HALLAM, C. C. DAY, J. N. TURNBULL

A Canadian firm required the development of a three channel tape recorder using standard quarter inch tape and operating for four hours. The response was limited to voice frequencies. Specially designed transistorized record and playback units solved noise and frequency compensation problems

During test flying, Avro Aircraft Ltd., Malton, Ontario, wanted to have a continuous record of the air to control tower conversations. It was also desirable to be able to separate the different channels of communication. This, with a spare channel, required a three-channel recorder capable of continuous recording.

As space was at a premium this precluded the use of Sonograph's standard equipment used by the Royal Canadian Air Force. Two units were therefore specially designed for the purpose, one unit being used for recording and the other for playback, though the two are interchangeable. Thus, by using an input signal transfer switch between recorders, continuous recording can be maintained.

Because of its easy availability as a standard item, 2,400 feet of ¼ inch Mylar magnetic tape on a NAB 10½ inch hub was used, and it was run at 1⅞ inches per second to give a continuous recording time of four hours plus. The tape was magazine loaded to enable quick changes to be made, and to eliminate handling of the tape itself. The interruption for changing was in the region of three seconds only.

The biggest difficulty encountered was partly electronic and partly commercial. To use a staggered head system would mean using seven heads in all; one whole track erase, three record, and three playback. This system was too clumsy to be satisfactory. Three track heads, the alternate solution, were not readily obtainable. Even those available were very costly. Due to the size of the coil structure on each limb of the head laminations, if the heads are stacked up on top of each other, there has to be a considerable space between tracks. This means that most multiple heads are designed so that two of them, staggered vertically by one track width, will give double the number of tracks over one head width. The head finally selected was designed for staggered use to give six tracks on ¼ inch tape. Thus, allowing for a small space between tracks, each track utilized only 0.0225 inch, or less than one tenth of the available tape width.

Correction needed in the treble

The maximum output of this low impedance head at 1⅞ inches per second was 150 microvolts at 700 cycles

*Sonograph Engineering & Mfg. Co. Ltd., Toronto

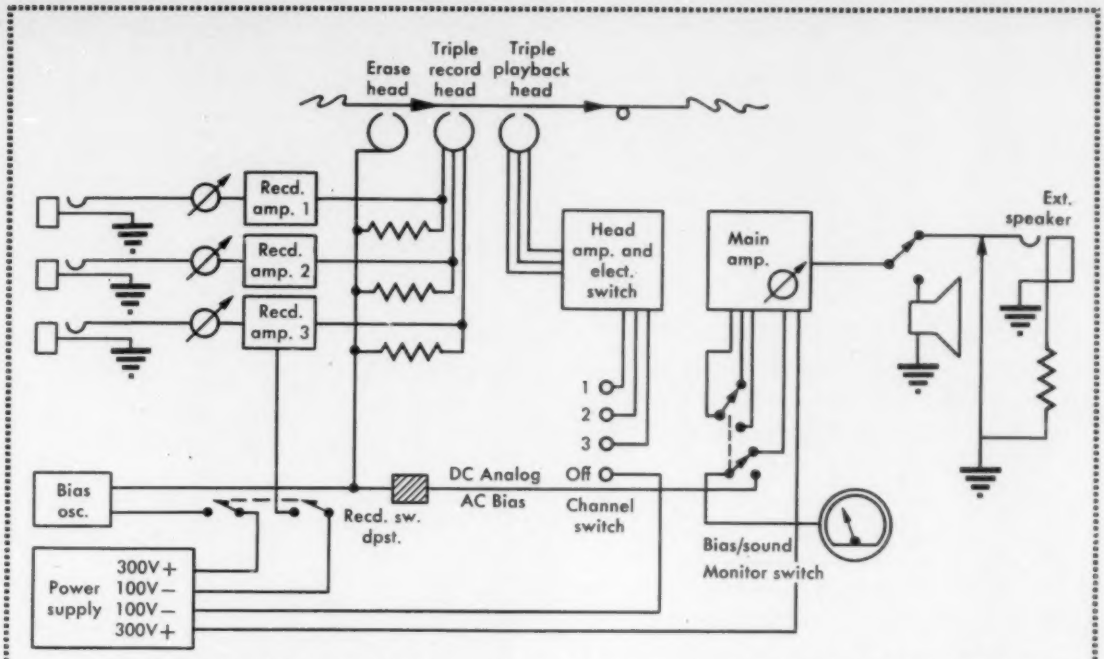


Fig. 1. Block diagram of three-channel tape recorder used to monitor conversations during aircraft flight tests

per second. Hence an average signal of about 50 micro volts dropping off above and below this frequency was to be expected. Due to the large gap width of .0004 inch and the consequent low turnover point of 700 cycles per second, most of the correction needed was in the treble where about 18 db boost was required to resurrect 3,000 cycles per second. Thus, a compromised frequency response of 300 to 3,000 cycles per second plus or minus 3 db was adopted. This limited bandwidth was more than adequate for the intelligible reproduction of speech. The treble limitation cut off at 3,000 C.P.S. to remove the large amount of static noise usually encountered on aircraft radio systems. A block schematic of the equipment is shown in fig. 1.

Playback Circuitry

So that the recording could be monitored while it was being made, the playback function was made as a completely separate unit from the record amplifiers (fig. 2). The use of transformers to step up the signal voltage would be both costly and liable to hum induction and, as it was impractical to switch at this low signal level, three separate transformer input tube stages would be required. The alternative use of transistors was a very tempting proposition; however as a large amount of heat is dissipated in a machine of this type, adequate thermal stability becomes a serious problem. By using a 100 volt negative power supply voltage, unusually high for transistors, and feeding into a conventional vacuum tube circuit, a voltage gain of 1,000 can be realized in a single stage. Although this configuration gives a low input impedance, it is still greater than that of the head by a factor of ten times. Thus the head was not appreciably loaded by the amplifier. If the base stabilizer potential divider is taken from collector to ground, stability factors of a little over two are easily attainable. This is much lower than that of the normal current amplifier stages and makes thermal runaway virtually impossible.

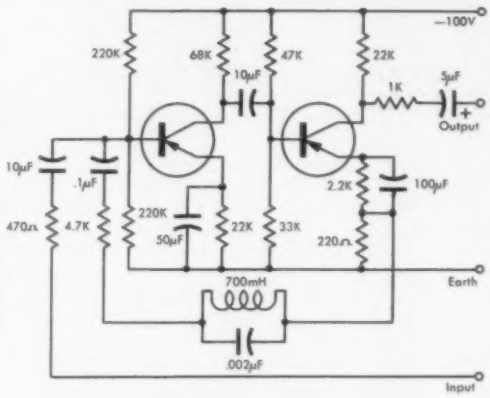


Fig. 2. Record amplifier uses two pnp transistors. Response approaches inverse of tape characteristic

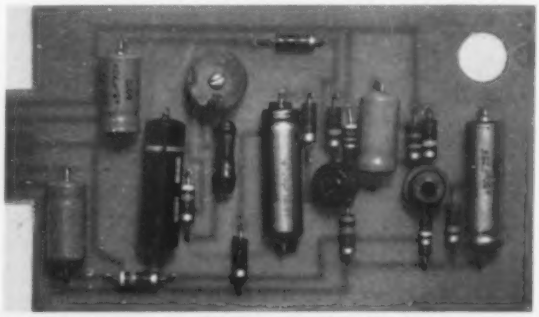


Fig. 2a. Record amplifier uses printed circuit on epoxy bonded glass fibre card. Contacts are gold flash plated

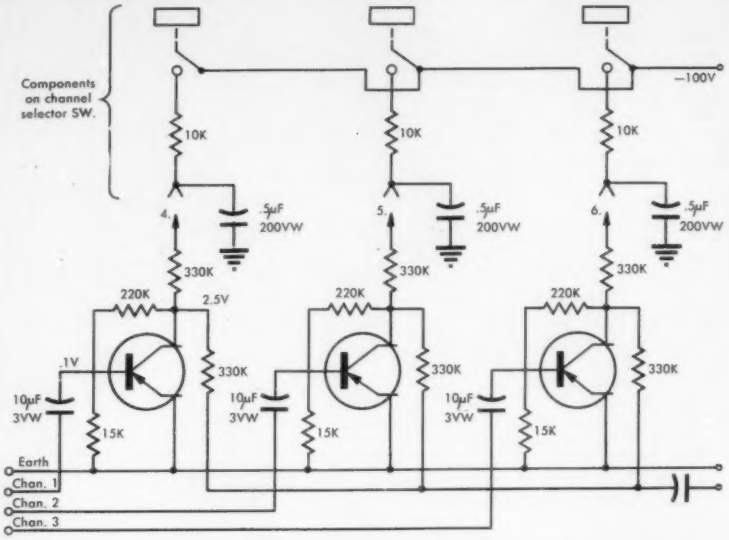


Fig. 3. The playback amplifier is in two parts. This is the head amplifier and electronic switch consisting of three separate high voltage transistor amplifiers. They are brought into operation by application of −100 volts and may be operated separately or together as a mixer.

Method of channel switching

The application of supply voltage to the stage offered a good method of channel switching (fig. 3). The signals from the three parallel stages were then fed into a high impedance current mixer. Thus the whole unit, built on a printed circuit board four by two by one half inches, solved the problem of high gain, low hum stages, low level switching, and mixing. It was small enough to mount directly beneath the heads themselves. This positioning near the heads helped to reduce the hum induced in the low signal line.

The rest of the playback amplifier (fig. 4) was a conventional tube circuit except that a high gain starvation circuit within the output feedback loop was used to give a low impedance and low distortion without too much sacrifice in gain. A modulation level meter with a quick rise and slow fall time was connected into the output to enable the record gain to be adjusted to full modulation. The gain of the playback amplifier was fixed at a predetermined level while metering.

The playback characteristic rose gently from 1 kc to 3 kc, then was steep cut at 12 db/octave to remove tape noise. It also cut off sharply below 200 cps to reduce hum. Although normally for maximum output, tape should always be full depth recorded and compensation should take place on playback, the expected input signal was rather lacking in bass, so the small amount of bass boost that was required could be added during the record function without danger of saturating the tape. This helped to reduce the amount of hum apparent on playback. If the large amount of treble boost that was required was all put on playback, tape hiss would become very noticeable and the signal to noise ratio would be reduced. If the boost, on the other hand were all put on record, due to the large amount of treble information coming through on the input signal, there would be a danger of over-modulating the tape. However, if a fundamental of over 1,500 cps were over-modulated, the second harmonic distortion would be above the frequency response of the system; therefore, although the tape would be over-modulated, the unpleasant harmonics produced thereby would not be heard on playback. For this reason most of the treble compensation was made on record, with a half section filter in the playback amplifier to give the rest of the boost, followed by a steep cut to reduce the tape hiss.

In all of the problems encountered in this machine there was never a simple or straightforward answer. The conclusions reached were always a compromise between signal to noise ratio, frequency response and tape saturation.

Plug-in units

When considering the record amplifier in a machine for this purpose, the primary concern was that the system be maintained even in the event of a minor breakdown. Thus each record amplifier was made a plug-in unit, as was the bias oscillator. The oscillator output is indicated on the meter when it is not being used for record level setting, so that oscillator failure can immediately be detected. The record amplifiers themselves were two stage transistor units built on a glass-fibre-epoxy-resin base printed circuit board. The circuit, which also forms the plug contacts to the cable-form socket, was gold flashed for protection and for good contact. The whole forms a very robust unit, and the prototype was subjected to impact velocities of 20 ft. per sec. without showing any mechanical or electronic deterioration.

Electronically the circuit again uses a 100 volt line. Over-all frequency sensitive feedback is applied to give the correct recording compensation. Because transistor gain was sensitive to line voltage fluctuations, neon stabilizing was used on the power pack on the 100 volt line. As the expected signal input level was in the region of zero dbm the gain required in the record amplifier was very low. It therefore served only as an isolation and frequency compensation stage.

Tape handling

The mechanical handling with this type of machine also offered its problems. It had to be fast, simple and foolproof. High torque motors of 1/25 hp were employed to wind or rewind 2,400 feet of tape in under two minutes. Using NAB 10½ inch reels, considerable tape diameter differentials were experienced. The drive had to be both

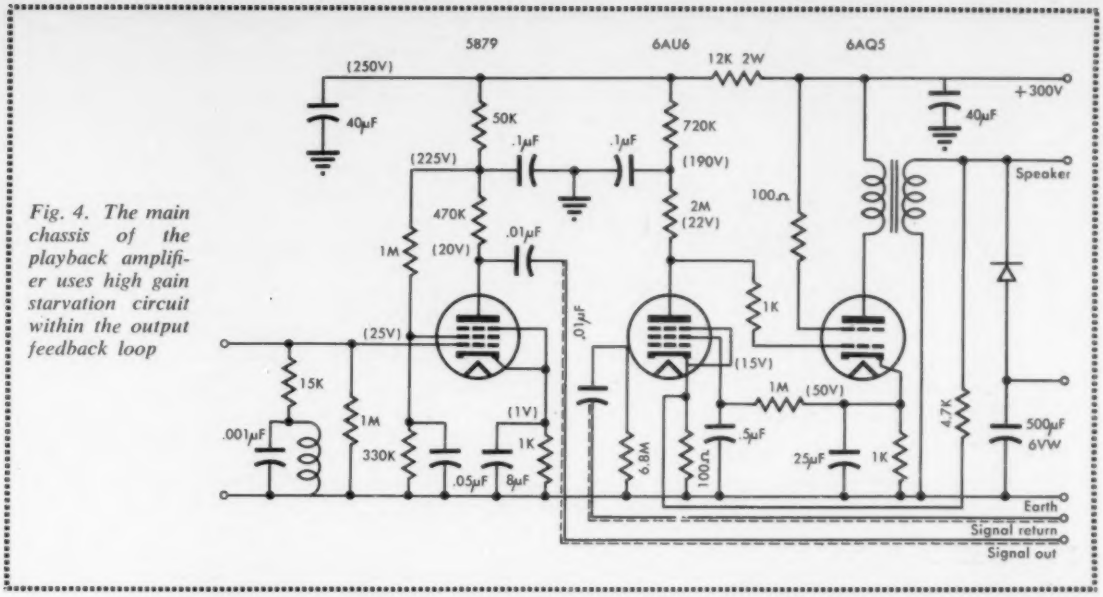


Fig. 4. The main chassis of the playback amplifier uses high gain starvation circuit within the output feedback loop

powerful and positive if a smooth, uniform tape speed was to be maintained. A six-inch diameter brass flywheel was belt driven by a third motor and, as the capstan diameter was small, considerable rotational momentum was achieved. This gave a wow and flutter at 1⅞ inches per second of less than 1%, the take-up torque having no measurable effect on tape speed. Solenoid operated band brakes designed to give differential braking were used. Thus the whole machine can be electrically push-button operated. A time delay was incorporated into the record/playback function so that it could be operated from the fast-run functions without tape spillage. The fully electrical operation had the advantage that, if required, the operation of the machine could be remotely controlled using only an electrical link.

The over-all machine is a little larger than a conventional tape recorder and measures 22 inches by 16 inches by 12 inches, and weighs 120 lb. However, when it is considered that it is the equivalent of three recorders and one playback unit the saving in space can be appreciated. Fig. 5 shows the unit with the front cover removed, disclosing the record amplifiers and oscillator. They can safely be withdrawn, even while the machine is in operation. Thus, if one fails, the signal can be transferred to the third (spare) channel and the amplifier for the channel which has failed can be replaced without any interruption in the operation of the machine.

These two machines have now been in use in the control tower of Avro at Malton for several months. The results, as have been observed, have shown that a smooth frequency response over a limited bandwidth is all that is required for the intelligible reproduction of speech. No trouble has been experienced in the use and operation of the hybrid circuits used in this machine.

The system having been established and the difficulties of narrow track playback having been overcome, this arrangement could, with the addition of three more record amplifiers, two more heads and the extra wiring in the cableform, be extended to six channels on ¼ inch tape. This has in fact been done on an experimental laboratory model. By employing wider tape, the number of channels is limited only by the constructional difficulties in interconnecting the various units. END

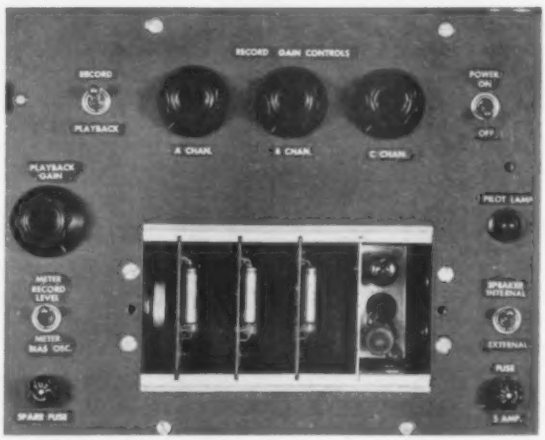


Fig. 5. Panel on front of the recorder is easily removed to gain access to record amplifiers and bias oscillator

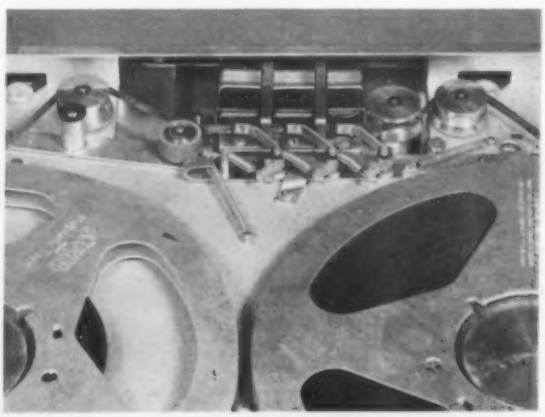
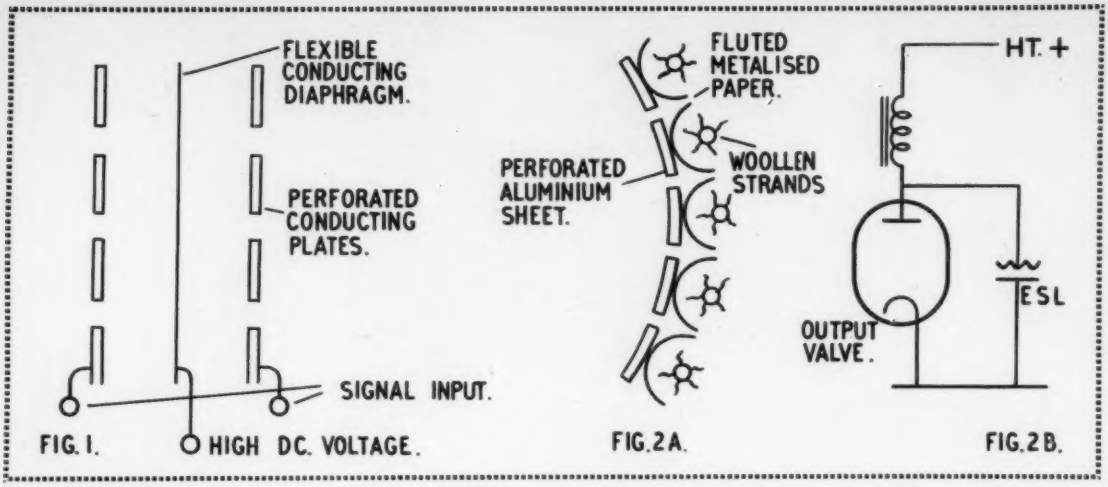


Fig. 6. Tape is contained in magazines for rapid handling. It automatically aligns with heads when tray is inserted



Audio forum

Electrostatic speakers provide live sound

The idea of electrostatic loudspeakers has been known for some time and experimental models were demonstrated as far back as 1881. However, only recently have they been available commercially. One of these, the Quad electrostatic, was subjected to a number of tests by the author. "The opinion formed was that it did perform as the very convincing theory suggested. All sensation of listening to a loudspeaker is lost."

Ralph West*

There are many ways of converting electrical energy into sound, but only two main ways have been utilized successfully up to the present. One uses the interaction of magnetic fields produced by a flow of current, and has been developed to a very satisfactory level of performance in moving coil and ribbon speakers. The other uses the attraction and repulsion of electric charges, and though the existence of these forces has been known at least as long as our knowledge of magnetic forces, only quite recently have we been able to exploit it to our satisfaction. The bare essentials are shown in fig. 1. A thin plastic sheet is given an electrically conducting coating and suspended between two rigid perforated metal plates. The plastic diaphragm is charged to a high voltage, and when signal voltages are applied to the outer plates, it will move, pulled one side and pushed on the other. As the signal is an alternating voltage, the diaphragm motion will be to and fro, and will drive air through the perforated metal plates. This we shall hear as sound.

* Reprinted from Hi-Fi News, November 1957. Miles Henslow Publications Ltd., London, England.

A little history

The first public demonstration of electrostatic devices was in 1881, when Dolbear exhibited a complete ES telephone system at the Paris Electrical Exhibition. Between 1920 and 1935 several ES speakers and microphones were made, mainly in Germany. In Britain the Primustatic speaker retailed for 25s. in the early 1930s. It consisted of a single perforated aluminum sheet, and a fluted metallized paper diaphragm. The insulation was partly a special lacquer on the perforated sheet and partly the fluted paper, which was waxed. Hairy strands of wool held the fluted diaphragm in place but allowed movement. The whole was curved to produce wide-angle radiation of the higher frequencies. The speaker was usually connected as in fig. 2b, when the pd between anode and chassis partially collapsed the thin diaphragm on to the fixed plate. Signals increased and decreased this pd, causing more and less attraction respectively, and corresponding movement of the diaphragm and the air surrounding it. It worked very well at high frequencies, but as the program material in those days had no high frequency content other than microphone hiss and record surface noise, it never became popular. We will appraise its technical capabilities later.

For the next twenty years, the only ES audio devices in general use were condenser microphones. Some of these were superb, and one of them undoubtedly played a vital role in the success of "ffrr" in its early days.

While the mechanical simplicity remained a tantalizing attraction to acoustic engineers, the known high distortion when used as a loudspeaker slowed further development. Soon after, the Second World War provided other and more urgent problems.

In 1954, Prof. F. V. Hunt's book "Electroacoustics" provided the key to the distortion problem. He gave a very rigorous mathematical examination of the ESL in various forms. His calculations showed that in push-pull form, like fig. 1, it was capable of handling large signals without much distortion if the diaphragm was given a

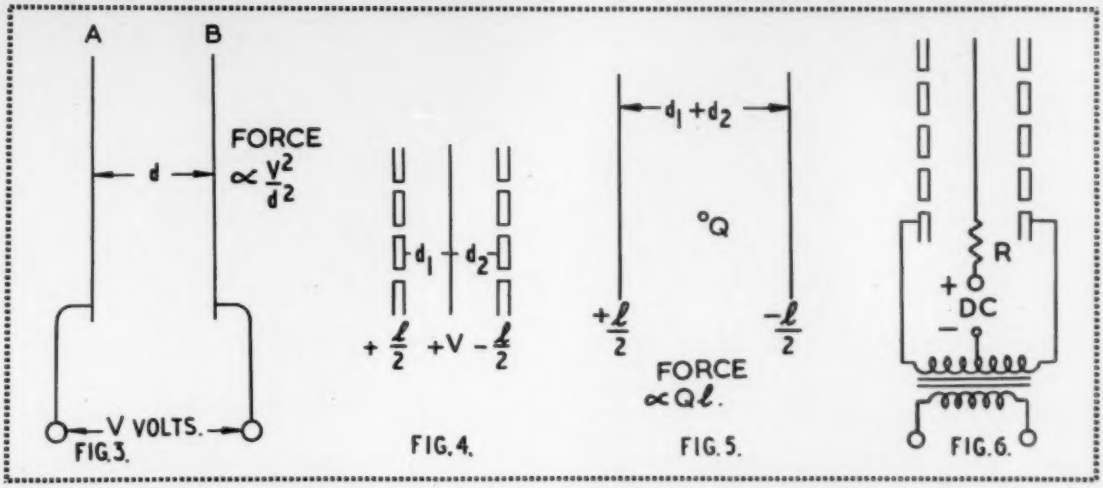


FIG.3. FIG.4. FIG.5. FIG.6.

constant charge instead of a constant potential or voltage. The push-pull form was not new; models were on sale in Germany around 1920. But the constant charge idea was new and once more work began in ESL design.

By 1955, P. J. Walker of the Acoustical Manufacturing Co., had produced two laboratory models, and these were demonstrated at the B.S.R.A. Annual Exhibition in May, 1955. One was open back and front and handled middle and high frequencies with amazing clarity. The other covered the whole frequency range with equally good quality and used a large closed cabinet or infinite baffle to maintain its bass response. The completely open type was further developed to cover the whole frequency range, and in March, 1956, it was demonstrated to the Physical Society in this form. This was the world's first full-range ESL in open or doublet form.

Between these two events, H. J. Leak had demonstrated a very successful ES tweeter (above 1,000 cps) and in America several ES tweeters appeared. By April, 1956, at the Audio Fair three ES units were being demonstrated; the newcomer was another full range model by Goodmans.

What does the ESL offer?

Engineers are sometimes upbraided for undue enthusiasm over the advent of the ESL. (The writer is still unrepentant). It is not without just cause. For years, acoustic engineers have been trying to move air with devices loaded with lumps of metal—iron (not recently), copper (very often), and aluminum (in the better ones). The thing that actually pushes the air (the diaphragm or cone) is rather heavy too. It has to be stiff enough for at least most of it to move together, though it is only pushed at one place. Now the moving parts of the ESL can be pretty well as light as we care to make them. The driving force is equal all over the diaphragm, so it does not have to be stiff enough to be rigid. It need be little thicker than just sufficient to support itself. This gives it a tremendous advantage as far as high note reproduction is concerned, and, what is probably even more important, transient response.

In fairness to the moving coil speaker, the better samples we enjoy have reduced these unwanted effects to such small dimensions that they are not obvious, not even to the experienced ear. However, the ESL having such a fantastically small weight per unit working area, just doesn't suffer from this trouble—or at least has no need to. (As far as the HF response is concerned, the ribbon speaker, too, can give similar results.) Even the bass response can be superior. If we can use a very large diaphragm, no cabinet is necessary and therefore no cabinet resonances and consequent coloration can occur. This is not very convenient with a single MC speaker, since the necessity to retain a cone shape in the interests of rigidity, results in a depth which is usually greater than half the diameter. A more suitable alternative is to use several speakers of more acceptable size mounted on a flat baffle, and a very successful design of this type has appeared quite recently.

Large amplitudes: little distortion

However, the ESL again scores heavily, since even very large amplitudes of movement are possible with very little distortion. The moving coil, unless an extremely costly magnet design is used, tends to "run out of field" at extremes of displacement. This leads to distortion and also to intermodulation, which is more serious and more noticeable. The driving force on the ESL diaphragm is undistorted for all deflections short of hitting the "stops." At very low frequencies there will be a little distortion due to the stiffness of the diaphragm necessary to prevent collapse. This is strictly comparable with the non-linearity distortion of the MC due to its surround and centring. The ESL is, however, practically free from intermodulation since the driving force for the higher note component is still intact, whereas for the MC, the driving force falls for large displacements as the coil is part way out of the gap.

A further advantage arises with the choice of the doublet type speaker, i.e., open back and front and radiating equally. At low frequencies, where its width (and height) is small compared with a wavelength, it only radiates energy in two directions—forwards and backwards in two very broad beams. (At higher frequencies the beams are not so wide, but never become narrow as the radiating width is reduced.) No energy then is radiated upwards, sideways, or downwards, resulting in far less coloration due to the room. It particularly reduces trouble due to eigentones.

The constant charge principle and distortion

(a) The simple ESL: Consider first a simple ESL consisting of two elements only, e.g., Primustatic.

The steady force $\propto V^2/d^2$

Now apply a signal of e volts peak.

The maximum force $\propto (V+e)^2 = V^2 + 2Ve + e^2$

The minimum force $\propto (V-e)^2 = V^2 - 2Ve + e^2$

The increase is $\propto 2Ve + e^2$

The decrease is $\propto 2Ve - e^2$

This latter is smaller and represents distortion, mainly

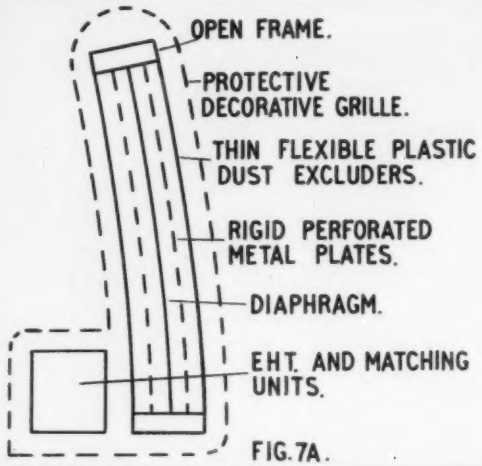


FIG. 7A.

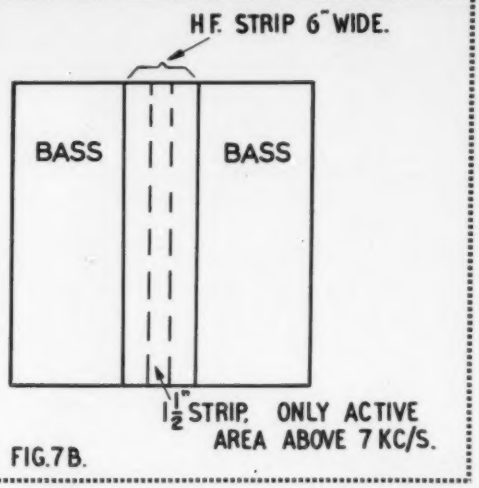


FIG. 7B.

second harmonic. Worse than this, when the force increases, the distance d decreases, further increasing the force. Results can only be acceptable, i.e., distortion small if V is very much greater than e at all times and diaphragm movements are small, i.e., small signals or as a tweeter.

(b) The push-pull ESL: If the diaphragm is central when the polarizing charge V only is applied, no movement occurs. Now apply the signal voltages and the net force becomes:

$$\alpha\left(\frac{V+\frac{e}{2}}{d_2}\right)^2-\left(\frac{V-\frac{e}{2}}{d_1}\right)^2$$

$$=\frac{V^2}{d_2^2}-\frac{V^2}{d_1^2}+\frac{e^2}{4d_2^2}-\frac{e^2}{4d_1^2}+\frac{Ve}{d_2^2}+\frac{Ve}{d_1^2}.$$

Now as long as the diaphragm remains central, $d_1=d_2=d$ say, this expression simplifies to net force $\alpha Ve/d^2$, i.e., it is proportional to the signal voltage e. This means no distortion as long as its diaphragm doesn't move! Still it was an improvement on the simple ESL, but not by any means good enough.

(c) The constant charge ESL: Referring back to fig. 4, when the diaphragm is displaced to one side, the capacity of that side increases while that of the other side decreases. A simple check will show that the increase is bigger than the decrease. Therefore, the net capacity has increased, and some extra charge would have to flow on to the diaphragm to maintain its voltage at V volts. If we prevent this flow, then its voltage will fall and the driving force will not rise so much due to deflection—in fact, not at all! Stated simply, the force on a fixed charge Q anywhere between the plates is only proportional to the PD (e volts) between them. This, then, is truly distortionless. In practice the "constant charge" has to be maintained against leakage via a very high resistance. This is made so high that the charge on the diaphragm doesn't vary appreciably during a half cycle of the lowest frequency to be handled. The diaphragm, though conducting, must be of very high resistance to prevent the charge "walking about" on it. Thus not only must the charge be constant, but the charge per unit area must also remain constant.

The acoustical Quad Electrostatic speaker

Description: All domestic equipment has to be a compromise involving size, weight, cost, technical complexity and performance, shape, finish, decor, etc. The moving coil systems, over a period of years, have settled down to fairly stable designs—there cannot be very much real difference in good speakers. With this new ESL speaker there is no design to follow, to improve on, etc., etc. The designer has had to decide his own selection of compromises and the general approval it has already received at its various public demonstrations, has shown the wisdom in the present choice. Time will tell whether we settle for this style, or some other. Meanwhile, it is definitely in the front rank of the best loudspeakers, on all scores.

The diagrams show most of the design features. High-note distribution is achieved by progressively reducing the active width of diaphragm with rise of frequency. In this speaker it is done in two main steps. The central 6 in. strip at 1,000 cps has a polar distribution that will match that of the whole area at low frequencies. Above about 7 kc only the central 1½ ins. radiates, again helping to keep the beam reasonably wide.

In the vertical plane the HF strip is the full height and, if flat, would produce a very narrow beam. The full length is needed to radiate the necessary energy, so adequate beam "height" is produced by curving the speaker.

The EHT unit is a small 50 cycle ladder-type circuit delivering a few microamps, at a few thousand volts for charging the diaphragm. It is therefore quite non-lethal, even if exploration with a knitting needle were attempted! The electrical consumption is negligible, barely more than the transformer iron losses, a mere few watts. The heaviest part of it is the matching transformer. This is a fairly high ratio step-up transformer having very low loss and distortion, and a bulky low-capacity sectionalized secondary winding—probably the most difficult bit to design!

Inspection with a torch shows the "rigid perforated plates" to be very thick indeed—as they should be if they are to remain effectively rigid a large amplitude low frequencies. The whole acoustic unit is sealed between thin plastic films (having negligible acoustic effect) to prevent ingress of dust and moisture.

Over-all height is 31 in., width 34½ in., and over-all depth is 10½ in. Weight is 35 lb. and it is thus easily moved by any adult member of the household.

As this speaker presents a rather different load to the amplifier from that of a moving coil type, certain requirements must be met. At frequencies above 8 kc it presents a capacitative load, just about the reverse of a moving coil unit, which is inductive, as a rule, in this region.

It was designed to work with the Quad 11 amplifier, but any equivalent amplifier can be used.

Specific amplifier requirements

1. When adjusted to a fixed suitable output tap, the amplifier should be capable of delivering at least 15 watts at low distortion when a resistive load is varied between 30 ohms and 7 ohms.

2. The amplifier must be statically and dynamically stable, regardless of the resistance or reactance of the load. An inductance of up to 10 h may be inserted in series with the load during these tests.

3. With a 30 ohm resistive load, the amplifier should at no time be capable of producing more than 35 peak volts across the loudspeaker terminals.

4. The source impedance of the amplifier should be not more than 2 ohms in the frequency range 100-5,000 cps and not more than 6 ohms in the range 40-20,000 cps. Ideally this impedance should be equivalent to a 1-2 ohm resistor in series with a 40 h inductance.

Performance: The reviewer has heard this speaker on many occasions previously, in a wide variety of surroundings, including a pair, giving stereo reproduction. The opinion formed, was that it did perform as the very convincing theory suggested. Not until it was actually on the "home pitch," however, was it realized how far this speaker is ahead.

There is no doubt music sounds very nice, more like the real thing than ever before. Speech, too, has lost all trace of boom—and that's not due to lack of bass. Another interesting feature is the complete lack of any fatigue effect, unless, of course, the program quality is bad. All sensation of listening to a loudspeaker is lost.

To make sure that the reviewer's judgment was not influenced by the thrill of the technical novelty, a series of searching tests with familiar records, BBC FM, white noise, rapid switchover to other excellent and familiar speaker systems, was performed to try and find where it excelled, where it did not, and, if possible, why.

Without doubt, the transient response was superior to anything yet experienced. Several moving coil systems, notably a horn loaded one, could reproduce the transients, but not with the complete lack of coloration that the ESL could achieve. Well, this was expected, and now it has become actual fact. Again, in fairness to the MC types, some of the best produce such slight coloration of transients that it was only detected with certainty after direct comparison with the ESL. The "threat" of the ESL has cerainly produced remarkable progress in the MC field, so don't rush to throw them all away just yet!

Record surface noise is noticeably lower than with any MC system with comparable hf response, again demonstrating the freedom from hf resonances. (A horn-loaded speaker of good design will also produce less surface noise, but unless the horn design is very good and the crossover correctly balanced, it will still color this noise.)

When listening on or near the axis, the effect is as of an open window looking directly on to the performance. It is a clearer, wider view than anything hitherto, and the apparent distance away of the performer varies with the microphone placing at the studio. Variation of the volume control will also affect the apparent distance, of course. A few degrees off the axis is often better, as any distorted (slightly) top in the sound is less obtrusive.

Probably the most striking phenomenon is the fact that the resultant sound sounds less like a loudspeaker than any previous experience has provided. This is due to two things, first, the lack of coloration anywhere in the frequency range. It has no noise of its own. Secondly, due to its doublet form the room participates far less than usual. The listener is virtually transported to a front balcony seat.

With slightly poorer quality signals, the speaker is still not wasted, though the high frequency content would sound almost as good from a much cheaper speaker. The lower register is still clean and uncolored—"unobstructed" is a word that comes to one's mind when listening to it. For some time now, the reviewer has become aware of a peculiar sensation when listening to many loudspeakers. It was as if a pillar, or similar obstruction, was situated between the performance and the listener. This effect was practically absent in one particular speaker, and is completely absent when listening to the ESL. The phenomenon was explained by the realization that diffraction of sound round a solid object produces an uneven frequency response. Some frequencies are boosted a little, some are attenuated—about as much as a fairly well damped resonance would do. No resonance, flat response, no apparent obstacle! This is one of the main reasons for the expression "clear view" involuntarily coming to mind.

Readers will have gathered by now, that this is not a device for impressing the casual listener with one's hi-fi equipment. The top doesn't sparkle all the time, and the bass doesn't shake one's tummy all the time. It merely does what it's told, no more, no less. The bass response below 45 cps is down somewhat compared with many current loudspeakers, but it does not spoil enjoyment of organ tone, rather the reverse. It does not make every pedal stop sound like a big fat Bourdon. Every orchestral instrument is treated perfectly, especially the large bass drum—it is no longer in a big felt-lined box.

Various positions were tried, and while the room does not appear to participate so much, its position did have a considerable effect. Fig. 8 shows very roughly five positions tried. A and B were poor—and the published leaflet warns thus. C was much better, D, close to but not parallel to a low open (full) bookcase, was very good. E, similar to C, but closer, was also very good. The lady of the house will probably insist on helping to decide where it is placed, but never mind, it is not heavy to move!

To sum up: The "Quad" ESL is slightly ahead of all dynamic types on transient response and freedom from coloration; it is a loudspeaker designed to be listened to and enjoyed in the home; it will produce adequate sound level for realistic results; it is not suitable for attempting to show off "larger-than-life" impressive noises. It will not suit all tastes, but the reviewer can confidently recommend it as an excellent domestic speaker. As Mr. Briggs has recently demonstrated really convincing stereophonic reproduction with two completely dissimilar speakers, it is seriously suggested that one of the listener's pair of speakers should be a full range electrostatic—the perfect excuse!

END

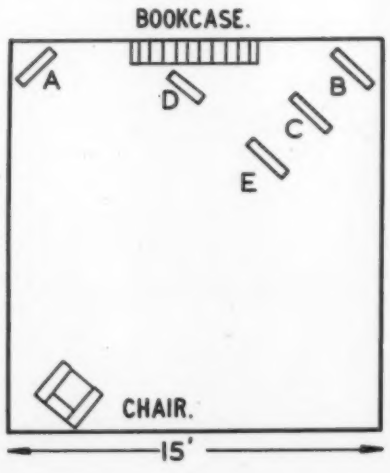
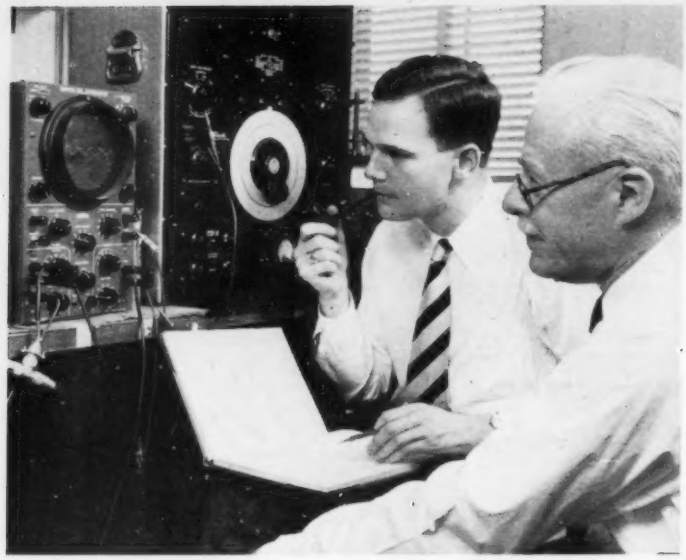


FIG. 8.



Research into transistor surfaces helps improve reliability

*C. G. B. GARRETT

In the manufacture of transistors, diodes and other semiconductor devices, inadequate control of surface technology may lead to serious degradation of initial performance and long-term reliability. Much of this trouble is known to be associated with a thin film of oxide on the semiconductor surface. Though much remains to be learned, recent experiments on the effects of light and of electric field on germanium surfaces have helped to establish the basic physics and chemistry of these effects.

When Bell Laboratories announced the transistor back in 1948, engineers held out hopes the latest electronic device would realize a 50-year-old dream: an amplifier that would consume practically no power, and would last forever. So far, it has never quite managed to fulfill the latter hope. Right from the start Laboratories engineers could see one reason why not: every transistor has a surface. And what went on there was a mystery. Many people realized the importance of cracking the problem. In several departments, an all-out effort was begun to find out what goes on at a semiconductor surface, and control it. Today, the job is half done. Many technological problems remain. But the surface is no longer quite the enigma it was. Understanding has been set on a solid groundwork of physical and chemical experiment and theory.

Transistors made of germanium or silicon are usually etched. Though quite clean by ordinary standards, an etched surface does not consist of just semiconductor and then nothing. There is always a film of oxide between the semiconductor and its surroundings, and the thickness of this oxide is not directly under one's control (one estimate: five atomic layers). Next, the oxide doesn't fit very well on to the semiconductor (fig.1). An open, porous material, rather like silica gel, the oxide soaks up water and metal ions, and hides them in the gaps and spaces in its structure. And quite tiny changes in the make-up of this oxide layer are important. Quite far into the semiconductor (for example: 10,000 atoms deep), the numbers of holes and electrons respond to small variations in the impurities present in the oxide. Sometimes, the oxide layer likes to give up electrons to the semiconductor, leaving the oxide positively charged. Inside the semiconductor, in a 10,000 atom deep, sub-surface layer, there must then be more electrons and fewer holes than before. Or the oxide may prefer to take up electrons, giving instead a surface region in the semiconductor having fewer electrons and more holes (fig. 2).

Imperfectly understood at the present time, the tendency of the oxide to donate or accept electrons is certainly a function of the precise impurities in the oxide, and so, of the surrounding medium. Whatever the exact mechanism, the charge acquired by the oxide layer is called "ionic charge," and is the most important factor in determining how the surface affects the device properties.

*Physical Research, Bell Telephone Laboratories

How does all this affect the operation of a transistor? To date, engineers have reported the following items:

1. The collector characteristic may not saturate properly, i.e., the collector current may be larger than it should be, and increase with collector voltage.

2. The breakdown voltage of the collector—that voltage at which the collector current suddenly becomes very large—may be low and variable.

3. The current gain (alpha) may be low.

4. There may be a direct, ohmic, path between the emitter and collector, giving something like a short circuit.

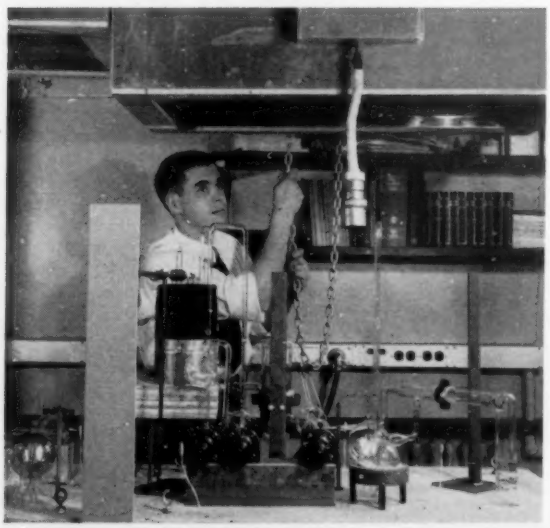
5. The emitter efficiency may be low, because of a direct ohmic path between emitter and base.

6. The noise may be high.

7. All of the transistor characteristics may change with time, particularly under load and at elevated temperatures. In extreme cases, the whole collector characteristic may "collapse" suddenly, in an irreversible way.

Why are these troubles blamed on the surface? Because they can be changed by changing the etching procedure, and are sensitive to the gas or other environment with which the device is surrounded. Figures 3, 4, and 5 show some of the reasons why.

Figure 3 shows an n^+p junction under reverse bias. ("n^+" means "heavily doped n-type"; "reverse bias" means that sign of bias which causes the junction current to saturate: in this case, the n^+ side positive and the p side negative.) Shown as a simple diode, this junction could also be the collector of an alloyed npn transistor. The n^+ side, properly a semiconductor, may be thought of as just a well-conducting sink for electrons. On the p side, the lines are drawn to show the flow of minority carriers (electrons) toward the junction, and they represent current flow under the reverse bias. The more lines, the more current, The illustration shows a number of these lines starting on the surface, at "surface traps." A trap is something that tries to maintain holes and electrons at their equilibrium concentrations. If there are too many carriers about, traps will help them to recombine: if there are too few, traps will generate some more. Near a reverse-biased junction, there are always too few, because, as fast as they are generated, they diffuse to the junction and get collected. So, the more traps, the more saturation current. And the number of traps depends on the state of the oxide, so on the surface treatment and environment.



Raising oven from ultra-high vacuum equipment used during investigations of clean surfaces of semiconductors

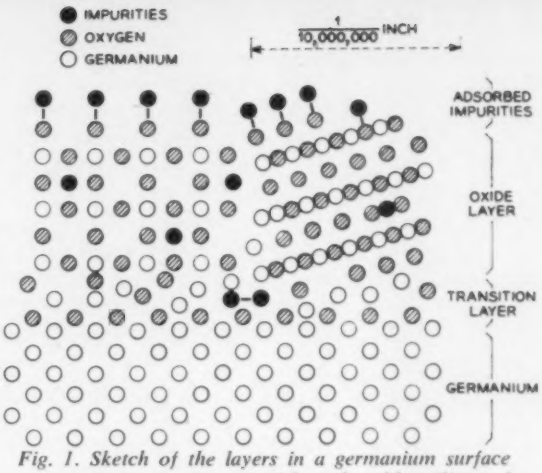


Fig. 1. Sketch of the layers in a germanium surface — an open, porous material, rather like silica gel

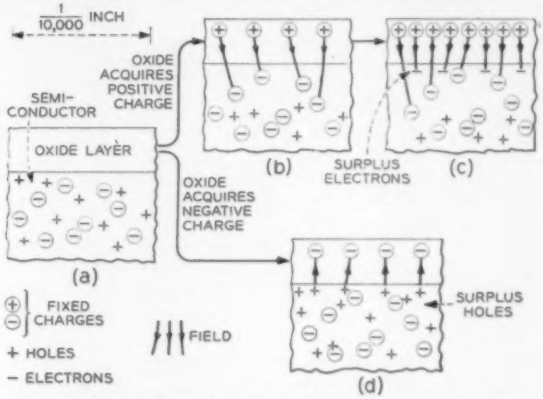


Fig. 2. Effect of varying the surface charge on carrier concentration near the surface — more electrons and fewer holes, or fewer electrons and more holes

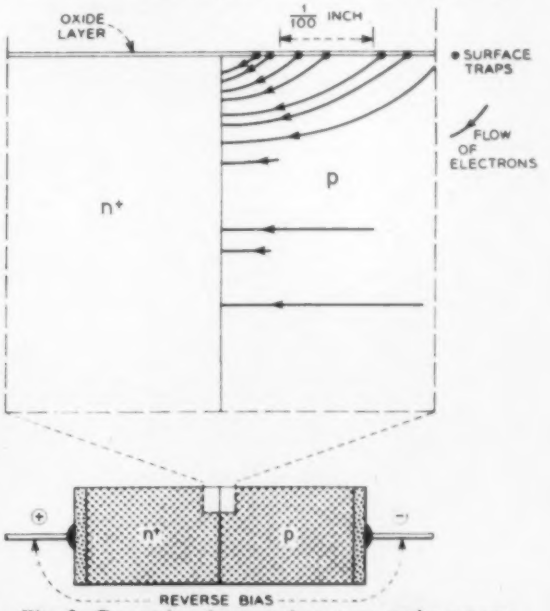


Fig. 3. Generation from surface traps under reverse bias — the more traps, the more saturation current

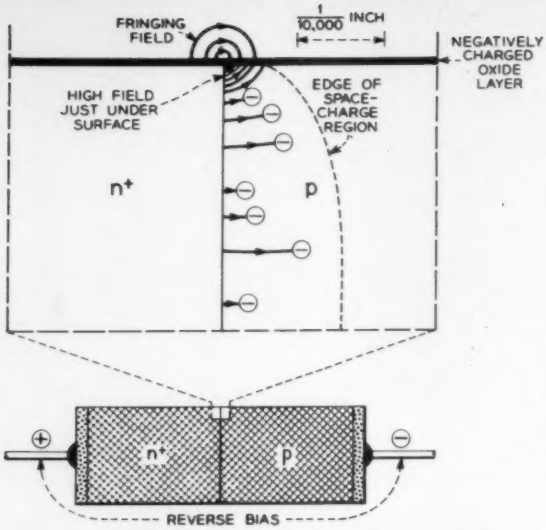


Fig. 4. Conditions for surface breakdown under reverse bias — the more lines, the greater the field

Drawn on a larger scale is fig. 4, which also shows an n+p junction under reverse bias. In this picture, arrows show lines of force (explanation: lines showing the direction of the electric field at each point; each line begins and ends on an electric charge; the more lines, the greater the field). Assumed negative is the charge in the oxide film, so that some of the lines of force can end there instead of in the body. The result is to reduce the width of the junction region near the surface and to pack the lines more closely there. The field being always highest just under the surface, breakdown occurs there first as the bias applied to the junction is increased. Now the breakdown voltage too is controlled by the surface, and so by what is done to it.

Effects of the fringing field

Also indicated in fig. 4 is the fringing field outside the semiconductor. This field is quite high (example: 100,000 volts per in.). If now the metal (or other) ions in the oxide are free to move, there arises a leakage current that further deteriorates the saturation of the junction. Worse still are the long-time effects. As the ions change their places on the surface, the arrangement of lines of force shown in fig. 4 must alter. The breakdown voltage thus varies with time. Particularly severe are these troubles when there is an appreciable amount of water on the surface (probable reason: because the ions are then more mobile).

Shown in fig. 5 is a more subtle surface effect. This picture shows a transistor with a peculiar ailment: over the base layer, the minority carrier of the interior (electrons in the p region) has become the majority carrier near

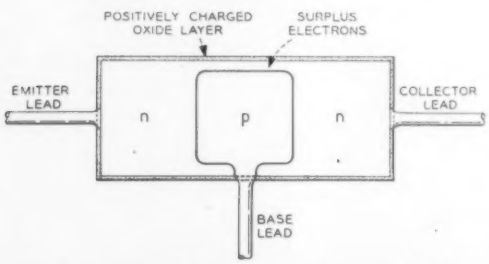


Fig. 5. Transistor with a channel across the base — this effect can be troublesome, even in diodes

the surface. Giving a direct ohmic path between the emitter and collector, this effect arises from a large positive charge in the oxide layer over the p-type base region (See (iii) of fig. 2). For an n-type base layer, a large negative charge would be called for. Called an "inversion layer" or "channel," this effect can be troublesome even in diodes. The "channel" effectively extends one region over the surface of the other, giving an increased area for the collection of minority carriers, and thereby increasing the saturation current.

The surface has not yielded its secrets easily. Much careful experimentation has been required to reach the conclusions outlined above. Much of the effort has gone into the problem of elucidating just how the holes and electrons are distributed in the surface region of the semiconductor. Of particular value have been two kinds of experiment: the study of the effects of applying an electric field normal to the surface, and the study of the various effects of illuminating the surface. Carried out with simple, single-conductivity type samples rather than transistors, these investigations have been pushed to the stage at which it is now possible to obtain quantitative information on the distribution of holes and electrons near the surface, and on the properties of the surface traps.

In a typical, straightforward, field-effect experiment, the apparatus might look something like that shown in fig. 6. The scientist applies a high field in a direction normal to the semiconductor surface, looks for a change in the resistance of the slice. Reason for the change in resistance may be seen from fig. 2. The numbers of holes and electrons near the surface respond to anything that sets up a field normal to the surface. In fig. 2 the field is shown arising from charge in the oxide film, but it could also be

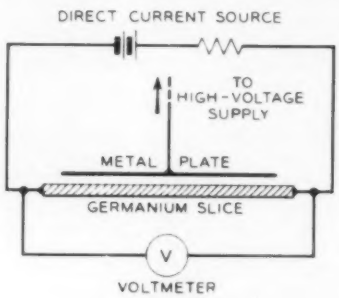
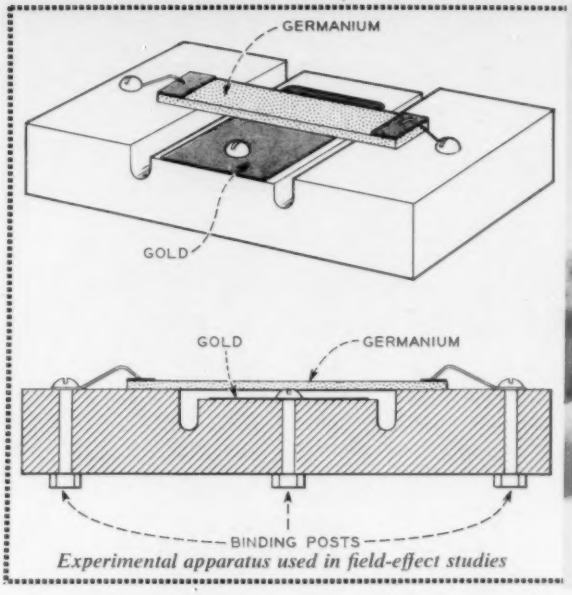


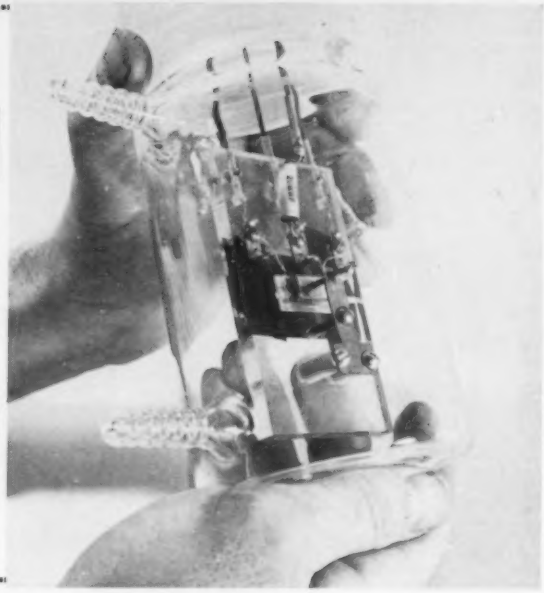
Fig. 6. The field effect experiment — are these the same surface traps?

an applied, external field. Coaxed into being by the application of a high voltage to the metal plate in fig. 6, the extra surface charge must appear as a change in the numbers of electrons or holes, and so in the resistance of the slice. But now comes the catch: not all the carriers that appear (or disappear) are (or were) free to conduct electricity. Some of them get trapped at the surface. During the last two years, scientists were debating the question: are these the same traps that generate extra current at the surface of a pn junction? Careful measurements of surface generation rates were set beside the results of field-effect experiments. The conclusion: the two sets of traps are the same. Pursuing the field-effect technique to its limit, scientists have been able to use it to determine the actual magnitude of the surface charge in the absence of field, i.e., whereabouts the field-free surface fits into the scheme of fig. 2.

Use of photo-effect techniques

The photo-effect techniques are also valuable. Drawn to show a particularly simple case, fig. 7 indicates the life-history of an extra electron created in p-type material by illumination of the sample, from its birth in the photo-





Experimental apparatus used in field-effect studies

excitation process to its death in recombination at the surface. The surface is drawn to correspond to case (iii) of fig. 2: there is a positive charge in the oxide layer, and a field directed away from the surface. Thus, the potential is higher at the surface than inside, as shown in the top diagram of fig. 7. In the second picture, an extra electron has been created by photo-excitation and starts moving in the direction of the arrow. (Against the field, since an electron carries a negative charge.) In the third picture, the electron has moved up to the surface, charging it up negatively and reducing the potential there. In the fourth diagram, the electron has been trapped. The potential at the surface is still low, but the electron is no longer free to take part in conduction. In the last picture, the electron has stayed in the trap long enough for a hole to wander up close to it. The electron and hole annihilate one another, and the surface has returned to its original condition.

Though this story is greatly simplified, it shows up the following effects of illuminating a sample, all of which are important and may be measured:

Photoconductivity. Extra carriers, created by light, add to the conductance of the sample.

Surface photo-voltage. Illumination of the surface changes, in general, the potential difference between the surface and the interior. This may be seen as a change in work function or contact potential.

Surface recombination. Extra carriers may be annihilated at the surface. This is the reverse of the process shown in fig. 3. Traps that can create carriers can also destroy them. Actually, the magnitude of the photoconductivity and surface photo-voltage in a given steady light depends on the surface recombination.

Making detailed studies of these effects, physicists have arrived at a fairly complete understanding of those surface properties of germanium and silicon that depend on the numbers of holes and electrons. Experimenters make careful measurements on the electrical surface properties of single-conductivity slices of material, and use them to interpret the surface-dependent device characteristics under the same chemical conditions. But this is not the whole story. Chemical control and understanding of the atomic layers outside the semiconductor is also needed. Aiming at the ability to produce a perfectly clean germanium surface, chemists have developed techniques for knocking off the contaminated surface region with accelerated rare-gas ions. The resuling surface has then to be preserved in ultra-high-vacuum (example: 1/10,000,000,000,000 atmosphere), to prevent new contaminants sitting down on the surface before one can make measurements on it. Then various contaminants can be introduced in a controlled way. These experiments are costly and difficult. But of one thing Laboratories scientists are confident: the chemical control problems will be mastered just as some of the physical ones have been. And a soundly based technological control will follow.

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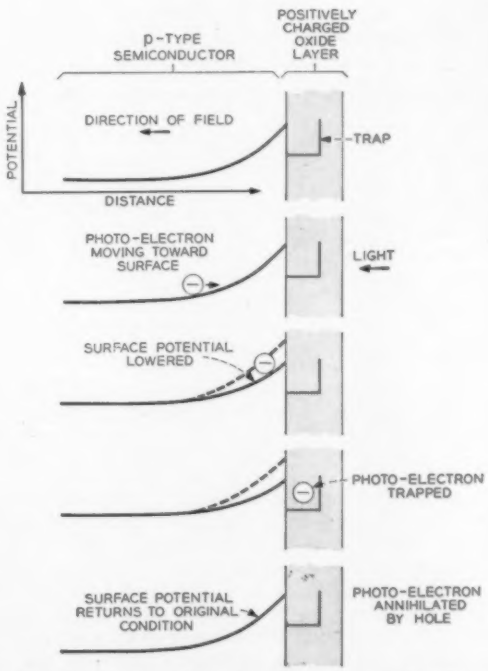
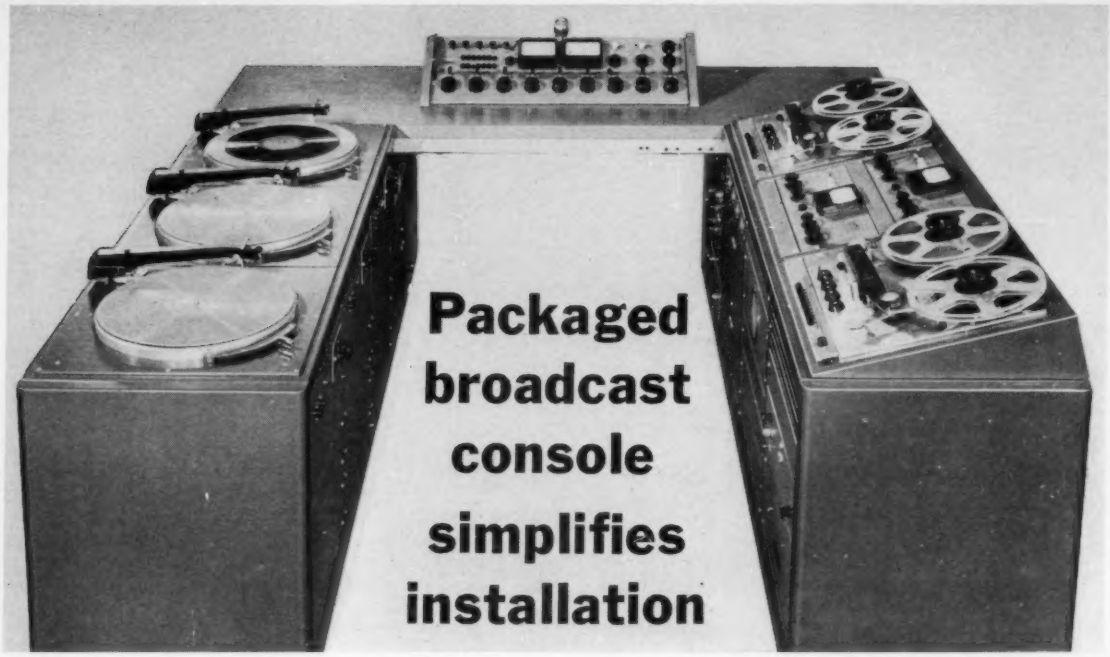


Fig. 7. The history of a photo-electron — the electron moves up to the surface and is annihilated by a hole



Packaged broadcast console simplifies installation

K. MACKENZIE*

The installation of broadcast studio facilities has, in the past, been largely a case of assembling small components in the field to try to form an integrated system. To avoid the problems of this method, a packaged control console system has been designed that can be installed in a few hours. It includes disc, tape, amplifier and control facilities that can be tailored to fit station requirements

In recent years there has been a tendency among manufacturers to preassemble as much equipment as possible to reduce time spent in the field. Along these lines a project was undertaken to design a completely prewired studio system which would, if possible, eliminated field time entirely. The benefits to be gained were many, not the least of which was a substantial reduction in cost. The result of the project was the SS4000 Packaged Master Control, as shown in the first photograph.

In this undertaking there were four main objectives

(1) To meet the requirements of modern programming techniques.

(2) To keep the entire assembly small and compact, unaffected by building peculiarities.

(3) A design flexible enough to permit the addition or subtraction of equipment depending on the customers' requirements and means.

(4) The elimination of field installation time.

Based on past experience and surveys among existing broadcasting stations, it was decided that the control room system must be capable of handling one studio with four microphones and two announce booths, each with one microphone. In addition, one man announce/operation must be possible within the control room. Two tape recorders, three turntables and incoming remote and network lines complete the list of available sources of program material. Since efficient programming involves recording and rehearsals while a separate program is on the air, a dual channel console was considered vital.

One man controls all operations

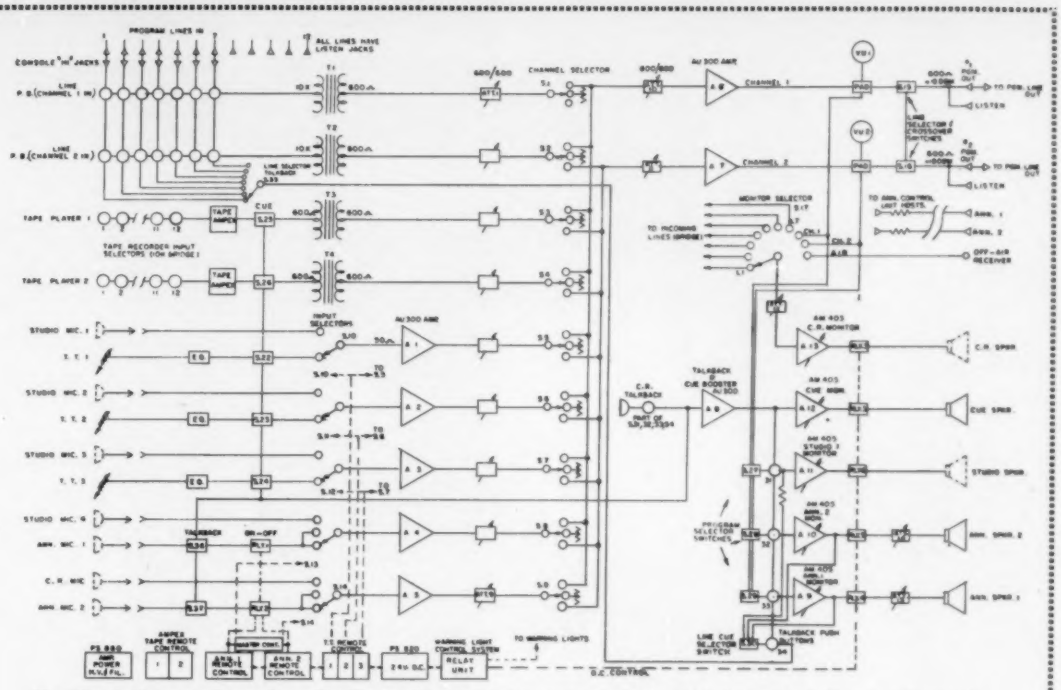
To facilitate announce/operation both turntables and tape recorders may be started remotely from the console, thus permitting the announcer to face the microphone. The remote start circuitry in each turntable also prevents "wow" starts over the air by delaying the sound approximately one half second, allowing the turntable to reach the correct speed. Cueing of the turntables and the tape recorders is accomplished by a pushbutton below each unit which breaks the feed to console and lights up to indicate the cue function. A row of pushbuttons for each tape recorder input permits the selection of console outputs or remote lines directly, without the use of patch cords.

Five individual monitor amplifiers for Control Room, Cue-Talkback, Studio, Announce Booth 1 and Announce Booth 2 are used; not only to provide greater flexibility but also to reduce the number of relays and the complex interlocking circuitry normally required.

Complete two-way talkback between the control room and the studio, announce booths or remote lines is incorporated, along with the necessary interlocks to prevent interference with an area on the air. The operator has selection of each location including individual remote lines. Announce booth facilities consist of a control turret containing pushbuttons for mic on, mic off, and talkback; a speaker level control and headphone jacks.

To complete the system all other equipment necessary, such as power supplies, jackfield and even a-c breaker panel are included.

*McCurdy Radio Industries Limited, Toronto, Ontario



Simplified diagram shows how SS4000 packaged master control can be varied to suit station requirements

The prime considerations in the physical layout of the equipment were to provide ease of operation and installation in either new or existing control rooms. Since some installations demand visibility into studios on three sides of the control room, the conventional tall equipment racks were done away with entirely. Instead, a U-shaped steel assembly is used. Its maximum height of 36 in. guarantees visibility in all directions, permitting, at least in new installations, greater freedom in building layout. With a length of 90 in. and a width of 80 in., a minimum of floor space is required. For shipping purposes the assembly is constructed of three plug-together sections, each self-contained and prewired.

The use of plug-in and plug-together components and equipment permit subtractions or additions to the standard system. Should the initial installation not require all amplifiers, tape recorders or turntables, these may be left out. Wiring, however, is always included for the total complement so that units might be added later with no modification or soldering. Since all cabinet surfaces provide standard 19-in. mounting, space is available for any other equipment that might be needed.

Plug-in amplifiers are interchangeable

All program amplifiers are Cartridge plug-in types. Regardless of their function in the system, they are identical and interchangeable in an emergency. The problem of stocking spare amplifiers is greatly reduced and servicing of defective units can be carried out properly in the maintenance shop.

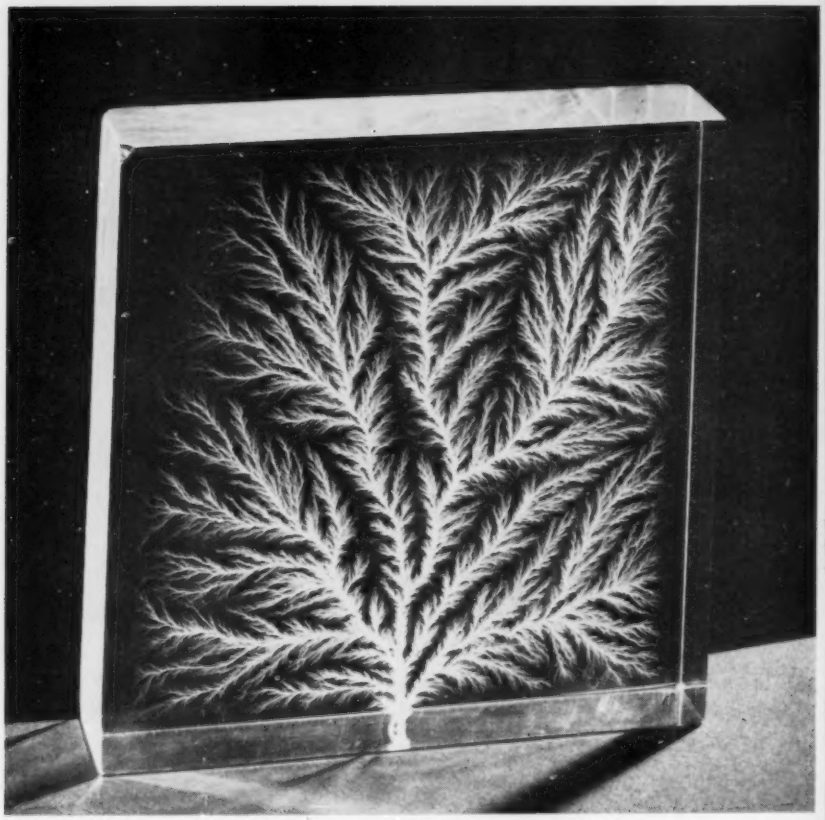
Careful layout, interwiring and testing, carried out under factory conditions guarantee consistent high standards of performance and workmanship. Installation can now be carried out with a minimum of time and effort on location and can, in most cases, be completed by station personnel. Even announce booth control turrets are prewired with connectors and multi-conductor cable, and with two-inch holes cut in separating walls, may be plugged directly into the console assembly. The only connections which must be made at the site are the following:

(a) 4 studio microphone lines.
(b) 1 studio speaker, 1 control room speaker.
(c) Program lines in and out (usually one 26-pair telephone cable).
(d) One 117-volt 60-cycle power line service.
(e) Signaling lights.

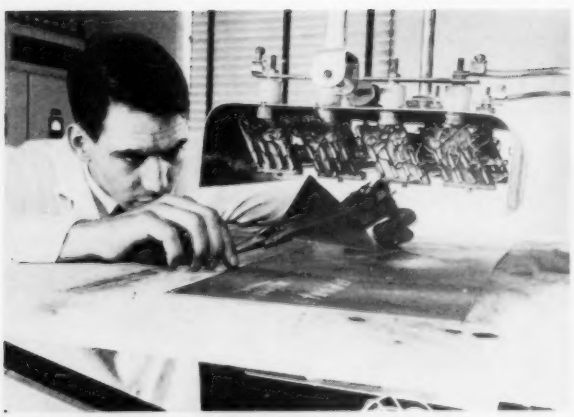
The first installations of this type have indicated a reduction in installation time from approximately 18 days to a total of 6 hours, and a substantial 27% saving in combined cost of equipment and labor compared with past installations of about the same size. END

All program amplifiers are identical regardless of their function in the system. They plug into rack

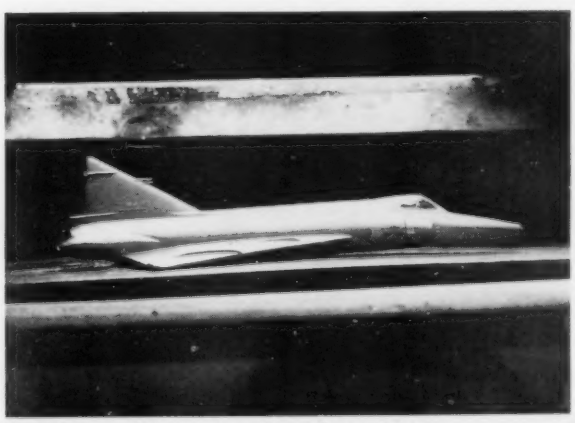
Electrons build their family tree



When Mullard engineers placed this perspex block in their 4-Mev linear accelerator, electrons penetrated about 2 cm, causing a charge to accumulate. Inserting a sharp pin into the bottom of the block released the charge, leaving this record of its path



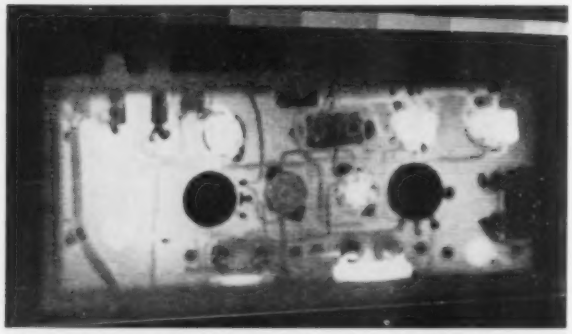
1 *Engineer places model under quartz infrared lamps of the Westinghouse high temperature tester*



2 *Plastic model is used to show effects of intense heating caused by air friction at high speed*

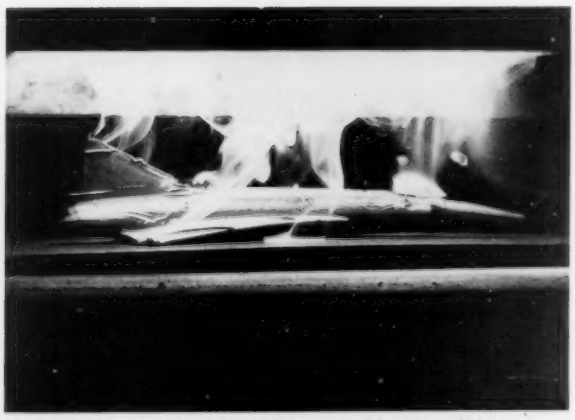
Transformer tree grown by Osborne Electronic Corp. has 500 separate conductors. It is used in a complex measuring and computing device

Thermograph shows that engine and exhaust are car hot spots

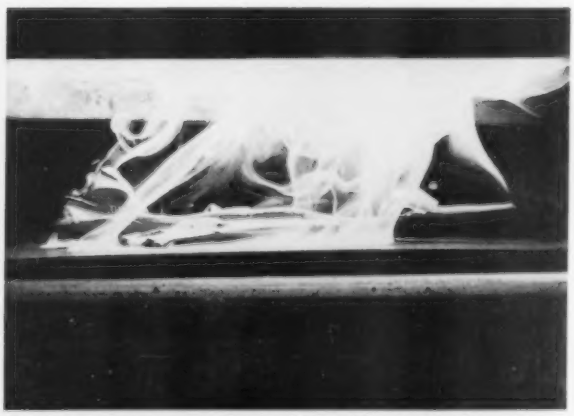


Heat build-up occurred in the resistors of this chassis

Stem of pipe remains near ambient. Pictures were taken with Barnes Engineering Co. Optitherm camera which scans subject with infrared detector. This modulates lamp scanning film. Temperature range is —170 C to +300 C



3 *Rapid heating closely simulates actual heat conditions met in flight. Model nears destruction after 4 seconds*



4 *Complete destruction in 6 seconds. The test facility can generate temperatures of 2,500 F within nine seconds*

For your library

Engineers must learn how to communicate effectively

Technical report writing

James W. Souther. John Wiley & Sons, Inc., New York; 70 pp; $2.95

"This book is an effort to make available to undergraduates and practicing engineers alike a short, concise, yet complete treatment of the fundamentals of technical writing. The treatment is basically a design approach; the principles of engineering design, translated to the terms of writing, are applied to the solution of reporting problems."

These words by the author in his preface describe well the aims and method of the book. No longer can engineers look upon the writing of reports as a necessary chore to be postponed or omitted if possible. Scientific and engineering projects of today are group functions and it is essential to have good communication between people within the group as well as between groups.

Engineering writing should be regarded as an important part of the profession and practised as such. Since the schools and universities in Canada have not yet given this phase of engineering due consideration, engineers must obtain their knowledge from other sources such as this book.

The author does not waste words on non-essentials. He tackles the problem logically by showing the reader what should be done, why it should be done, and how it can be done effectively. Each project can be approached as an engineering design problem and solved in much the same way. There are, in fact, four logical steps in turning out a good report. They are to: analyze, investigate, design and apply. The author has used the same headings for his chapters and comes up with a sensible text on the subject.

System Engineering

An introduction to the design of large-scale systems. Harry H. Goode and Robert E. Machol. McGraw-Hill Co. of Canada Ltd., Toronto; $11.50

Reviewed by: J. M. Toye, Manager, Design Engineering, Electronic Equipment & Tube Dept., Canadian General Electric Co. Ltd.

A tutorial treatment of a new subject "Design of Large-scale Systems," discusses the problem exemplified by specific traffic control, telephone toll switching, and combat strategy problems.

The tools now available for such problem solution are described in separate chapters headed "Mathematical Models," "Digital Computers," "Analog Computers," "Game Theory," "Information Theory," and others. Each subject is handled appropriately and with a good basic bibliography.

The intent of the authors is to suggest problem-solving techniques and in this way they are very successful in covering the wide field from which one must select the areas of interest in a particular problem or class of problems.

The book would be a time-saver in a general engineering library, elementary text for those entering the field of large-scale system design and a useful and stimulating reference for the smaller or personal library, since the techniques might find application in some small-scale system problems or even discrete design problems.

Ampex faxtape recorder

Catalogues and brochures from the manufacturers

Canadian radio frequency allocations chart, 34 in. x 30 in., full color, shows allocation of all frequency bands in Canada. Now available at 50 cents per copy, prepaid. Canadian Radio Technical Planning Board, 200 St. Clair Ave. W., Toronto 7. (101)

Synchros. Six-page folder presents characteristics of synchros, servomotors, resolvers, tachometers and tach. generators. Muirehead Instruments Ltd., Stratford, Ont. (102)

CLM-Darcy Relays. Catalogue R-58, 24 pp. on the proper selection of relay types, Canadian Line Materials Ltd., Toronto. (103)

Technical data on a-c and d-c components, gearheads and switches, breadboard components, 42 pp. Vactric (Control Equipment) Ltd., Montreal. (104)

X-ray diffraction, diffractometry and spectrography. Questions and answers in 13-page booklet. Philips Electronics Industries Ltd., Toronto. (105)

Vibratory bulk materials handling equipment is described in the 60-page condensed catalogue No. 5712. Syntron (Canada) Ltd., Stonely Creek, Ont. (106)

Ampex faxtape recorder for receiving, storage and re-transmission of facsimile. Eight-page descriptive brochure. Ampex American. Toronto. (107)

Electronic systems for national defense is described in 32-page book. Sylvania Electric Products Inc., New York. (108)

Reference data for radio engineers, fourth edition, by International Telephone and Telegraph Corp., $6.75. Acme Code Co., New York. (109)

Servomanometers are described in two brochures, bulletin 500 and special sheet 500SM. Exactel Instrument Co., Los Altos, Calif. (110)

Machmeter and true airspeed measurement is discussed in the late fall 1957 edition of Giannini Technical Notes. G. M. Giannini & Co., Inc., Pasadena, Calif. (111)

Microwave Associates facilities. Sixteen-page brochure describes history, personnel and activities. E. G. Lomas Co., Ottawa. (112)

Precision potentiometers. Twenty-six-page listing of potentiometers with specifications and design data. George Rattray & Co., Richmond Hill, N.Y. (113)

Precision interval timers by A. W. Haydon. Bulletin AWH RC-300 includes illustration, description of operation and design information. Philips Electronics Industries Ltd., Toronto. (114)

DC overpotential testing, its advantages and techniques are discussed in a technical bulletin from Bayly Engineering Ltd., Ajax, Ont. (115)

Application data for numerical position control. Bulletin GET-2676, 14 pp. Canadian General Electric Co. Ltd., Toronto. (116)

Saturable reactors told in "quick story," bulletin C-15. Features proportioning reactors, transducers and switching reactors. Control, Butler, Pa. (117)

Waveguide pressure windows, solderable and flange-mounted types. Data sheet CP11-1 lists characteristics, mechanical data and outline drawings. E. G. Lomas Co., Ottawa. (118)

Simpson WIDE BAND LABORATORY OSCILLOSCOPE

Model 2610

Designed and produced in Canada for the Canadian market, the Model 2610 represents a new approach to precision oscilloscope engineering at a modest price.

Major improvements in long term stability, frequency response and ease of operation have been effected. Features 5% overall accuracy from D.C. to 6 Mc/sec. on the Y-Axis; or rolled off response providing 75 Millimicroseconds rise time on pulse waveforms with less than 3% overshoot. Free running time base from 3 c/sec. to 500 Kc/sec., or calibrated triggered sweeps as desired.

In either application synchronizing and triggering is remarkably effective at all usable signal amplitudes throughout the passband of the amplifier. Signal delay of 0.3 microseconds is provided switched in or out as desired. Flexibility as to internal or external blanking, triggering, etc., is provided by interlocking switches, while complete shielding prevents stray coupling and pulse distortion. Y Amplifier gain in excess of 2,000 x provides deflection sensitivity better than 3.3 Millivolts R.M.S./c.m. Employs twenty-five tubes, including flat faced 5" type C.R.T.

Price including cables and line cord — $550.00. Sales Tax extra.

Bach-Simpson LIMITED

1255 BRYDGES ST. LONDON, ONT

Circle No. 12 on Reader Service Card

5000 watt triodes are water cooled for high plate dissipation

Two new Eimac audio amplifier or modulator low-mu triodes have 5,000 watts plate dissipation. Designated the 3W5000A1, and the 3W5000F1, they are water cooled versions of the 3X3000A1 and 3X3000F1, and except for higher plate dissipation, have the same ratings.

The 3W5000A1 has rugged concentric contact surfaces for socketing while the 3W5000F1 (illustrated) is supplied with flexible filament and grid leads. These tubes were designed for industrial application where the load encountered may be reactive as in vibration table drivers and ultrasonic transducers. They also may be used as a series regulator tube in electronically regulated power supplies.

D. D. B. Sheppard, Ottawa. (119)

Intercom set uses transistors

A portable transistor intercom, designed for duplex operation over 2 pairs of wires, operates in a manner similar to field telephones, but eliminates the need for head sets or hand sets. The transmitter or receiver units each have on-off switches but when the units are plugged together for transporting or storing, microswitches disconnect the battery. Four foot lengths of heavy line cord terminated in Pee Wee clips permit rapid connection to wires or cables. The operating range is at least one mile over No. 26 gauge conductors.

Four 1.5 volt penlight cells are required for the receiver and one 15 volt Ever Ready type 4¹1 for the transmitter. Average life of batteries under operating conditions of 8 hours per day is 100 hours.

Northern Electric Co. Ltd. (120)

Sweep generator has markers

The Kay mega-sweep model marker provides continuously variable sweep widths and centre frequencies from 50 kc to 40 mc. Frequency range in two bands is 10-500 mc and 400-950 mc. This instrument provides two series of marks through the harmonics of a crystal controlled oscillator at 5 mc and 50 mc. The crystal calibrators may be switched to either setting; the 5 mc crystal may be used to measure band width while the 50 mc frequency crystal may be used to determine centre frequencies.

The sweep rate is variable around 60 cps and locks at line frequency. RF output voltage on high range is approximately 0.5 volts rms into nominal 70 ohms and on low range approximately 0.07 volts rms into nominal 70 ohms. Amplitude modulation is less than 0.1 db/mc over frequency sweep.

MEL Sales Ltd., Arnprior, Ontario. (121)

Toggle switches have safety catches

A new series of Micro Switch three-position toggle switches have safety catches to guard against accidental operation. The safety catch holds the toggle lever in a "set" position and a pull of approximately .109 in. is required to release the lever for movement. Model 11AT has two basic switching units in each assembly while Model 115AT has four switching units. All switching units have single pole double throw arrangement. The basic switching units used in the switches are listed by CSA for: 10 amps, 125, 250 volts ac; ½ ampere, 125 volts dc; ¼ amp, 250 volts dc.

Honeywell Controls Ltd., Toronto. (122)

Mica capacitors have plastic coating

Radial leads for automation and plug-in assembly, small-size high operating temperature and a dipped plastic casing make the type ABM mica capacitors suitable for use in miniature electronic equipment. The capacitors are available in a wide range of capacitance and tolerance. Minimum initial insulation resistance is 25,000 megohms at 25 C and 1,000 megohms at 125 C. Operating temperature range is —55 C to 125 C. Special lead configurations are available on quantity orders.

Aerovox Canada Ltd., Hamilton. (123)

Four-speed turntable

A 4-speed turntable and pick-up arm have been designed for use in portable record players. Model BSR TU-9 is 8″ in diameter and handles records of all sizes and speeds. There is a built-in adapter for playing 45 rpm records. The motor, which is made to operate on 110 volt 60 cps, is equipped with a 25 volt tap, useful for single tube amplifiers where 25 volts are required for filament operation.

The pick-up is completely separate but matches the turntable in styling. It is fitted with a BSR "Ful-Fi" crystal cartridge with an adjustment for stylus pressure. The cartridge is available as a separate item and fits all standard pick-up arms. Response using the latest NAB curve is flat within ±3 db up to 12,000 cycles. Output of the turnover cartridge, model TC8-M at 1000 cps is 0.3 volts.

Another version of this cartridge, the model TC8-H is essentially the same mechanically but has an output of 1.0 volt at 1,000 cps.

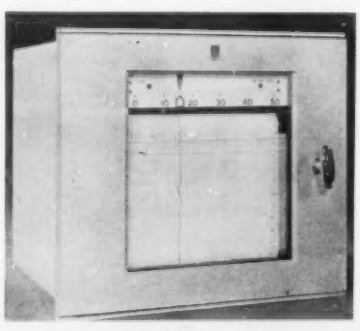
Musimart of Canada Ltd., Montreal. (124)

Electrostatic pre-amplifier and mv recorder

Model PR2201E Electrostatic Recorder is designed to record the output currents or voltages of high impedance sources such as ionization chambers, photomultipliers and photoelectric cells. It has an input impedance of greater than 10^{12} ohms and will measure and record currents of less than 10^{-14} amps or voltages produced by sources with an internal impedance up to 10^{9} ohms. Input voltages are compared to a known compensating voltage across a pentiometer supplied by a stabilized direct current. The difference voltage, after being applied to a two stage amplifier via a vibrating capacitor is fed to the recorder at a low impedance level. The recorder, therefore, may be located up to 150 feet from the voltage source, while the pre-amplifier is mounted near the source.

Six measuring ranges are available from 0-100 mv up to 0-1100 mv. The measuring accuracy is 0.25% of full scale for all scales except 0-100 mv where accuracy is 0.5%. Response sensitivity and repeatability are better than 0.5 mv. Drift is less than 1mv in 24 hours, or 5 mv per month. Any one of four chart speeds may be selected by rotating a knob on the chart drive mechanism gear box.

Philips Industries Ltd., Toronto. (125)

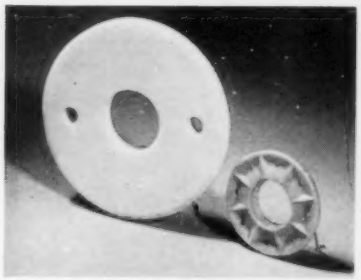


(Continued on page 41)

Components of Teflon

"Teflon" is being used in more electronic applications, particularly where space is at a premium, temperature is high and dielectric properties must be closely controlled. Illustrated are spacers for coaxial transmission line. Other applications are tube sockets, insulators and wire insulation. Full information may be obtained from:—

Du Pont Co. of Canada (1956) Ltd., Montreal. (126)



Ultrasonic cleaning equipment

Designed primarily for ultrasonic cleaning of small parts such as ball bearings, instrument movements, complex castings, printed circuits and tube parts, type 1150 equipment is small and compact. It operates from 200-250 volts, 50-60 cps mains and draws approximately 250 watts. Dimensions of the generator are 11″ x 13″ x 16″ over-all with a weight of 43 lbs. Operating frequency is about 40 kc, pulsed at 50 cps. The high frequency power has approximately 125 watts average, 500 watts peak.

Two sizes of tank transducers are available in which the radiating elements are assembled in the base of a stainless steel cleaning chamber. The generator is designed to drive at full power one immersible transducer type 1161/B36, or two half power transducers type 1161/B18. Alternatively, one two-gallon tank assembly type 1160/T52 or one ½ gallon tank assembly type 1160/C30. Switching is provided so that any two of these combinations can be used alternatively.

Dawe Instruments Ltd., Canadian Division, Ottawa. (127)

Transistor-magnetic amplifier power supply

The Perkin model MTR060-5 power supply utilities transistor-magnetic amplifier design. Specifications are: input, 95 to 135 vac, single phase, 60 cps; output voltage, 0-60 v dc; output current, 0-5 amps dc; ripple, 1 millivolt rms max.

Electromechanical Products, Agincourt, Ont. (128)

(Continued on page 42)

YES, try the **SERIES 304!**

When your available space isn't large enough to hold an active sand flea, but you must have a single turn potentiometer of utmost reliability and linearity, try the **SERIES 304**, a "flyweight" in the ranks of Daystrom precision, wire-wound potentiometers.

Check these outstanding features:

SIZE: 0.5" dia. by 0.375"

LINEARITY: Precision winding techniques give the **SERIES 304** a linearity of from 3% to 0.3% standard, or as good as 0.18% on special order.

RELIABILITY: The exceptionally rugged construction of this potentiometer gives it a service life of not less than 500,000 cycles.

STABILITY: Only materials of low (and similar) temperature coefficients are used in order to produce great stability under all temperatures.

AVAILABLE WITH: Integral shaft lock
Servo or panel mount
Rotational stops

Write **TODAY** for complete details on this and other precision potentiometers from **DAYSTROM PACIFIC POTENTIOMETER DIVISION!**

DAYSTROM LIMITED

840 Caledonia Rd., Toronto 19, Ontario
or 5430 Ferrier St., Montreal, Quebec.
A Subsidiary of Daystrom Incorporated.
5801

Circle No. 23 on Reader Service Card

international exhibition

INSTRUMENTS
ELECTRONICS
AUTOMATION

16-25 APRIL 1958 LONDON, ENGLAND

You are cordially invited to the 1958 Instruments, Electronics and Automation Exhibition.

MORE THAN 250 BRITISH MANUFACTURERS will be showing the latest and most comprehensive range of exhibits.

OVER 100 OVERSEAS EXHIBITORS will be displaying their achievements in the rapidly developing fields of instruments, electronics and automation.

Note the date NOW.

I.E.A. — the exhibition no progressive industrialist can afford to miss.

A conference will be held throughout the period of the Exhibition. For further details of both Conference and Exhibition contact the nearest British Embassy or Consulate, or write to:

INDUSTRIAL EXHIBITIONS LIMITED
9 ARGYLL STREET, LONDON, W.1, ENGLAND
Circle No. 24 on Reader Service Card

Radiography x-ray unit

Portable industrial radiography unit (MG 100) is housed in an enameled steel case measuring 16 x 12 x 6¾ in. and weighs 45 lbs. It is connected to the tube head through a flexible multi-conductor cable. Regulation is continuously variable through 30 to 100 kvp. The x-ray generator and tube are enclosed in a separate steel tank weighing 55 lbs. The 1 mm focal spot is eccentrically located within the tube head, closer to the port, permitting shorter focal-film distances.

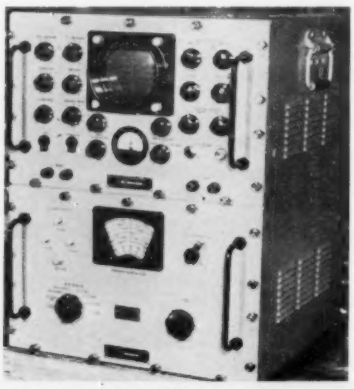
A radiation angle of 42 degrees allows wide field coverage amounting to 76% of the focal-film distance. At full load, 100 kvp at 4 ma, the equipment can be operated continuously for 50 min.

Philips Electronics Industries Ltd. (129)

Wide range spectrum analyzer

A band switch arrangement on the Lavoie spectrum analyzer permits coverage of the 10 mc to 21,000 mc range. Triple shielding allows operation in fields exceeding 4 megawatts without spurious responses. It has a shock performance of 37 g, 10 millisec duration in transit case, vibration of 10-55 cps, 10 g, and meets all environmental specifications.

Lavoie, Morganville, N.J. (130)

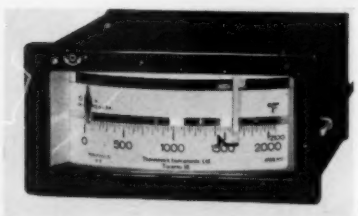


(Continued on page 43)

Temperature controller

This temperature controller uses either contactors for electrical operation or air operated valves, solenoids, or servomotors for controlling gas, oil, steam, hot water or other heating and cooling media. The primary temperature detecting elements may be thermocouples, resistance thermometers, or radiation tubes. Construction is such that failure in the electronic circuit or detecting elements will result in shut-off at the controller. Ambient temperature can be compensated and the minimum range of the controller is 8 mv. Sensitivity is 0.1% and the meter movement is a high resistance core magnet type. Various scale standards are available between —320 F and +5500 F (or equivalent C). Dimensions are 7½ x 3¾ x 8 in. Switching capacity is 6 amps at 110 volts (without contactor).

Thermovolt Instruments Ltd., Toronto. (131)



High temperature 2-watt variable resistor

Type 96 high temperature 2-watt military variable resistor is certified to meet MIL-R-94B Style RV4. Ambient operating temperature is —63 C to 150 C. It is available with spst switch, printed circuit terminals and a variety of shafts and bushings. It can also be furnished in 2 or 3 section concentric shaft and straight shaft tandem construction. All insulated parts are non-fungus nutrient hi temp silicon fibre glass construction. New design has closed openings under terminals.

C. C. Meredith & Co. Ltd., Streetsville, Ont. (132)

Copper-clad glass supported "Teflon"

Now in production is glass-supported Teflon tape with copper foil bonded to one or both sides for use as etched flexible cable harnesses for missiles and aircraft, or as flexible connectors for multiple array printed circuit "stacks" for computers and control devices. Electrolytic copper foil in weights of either 1 or 2 oz. per sq. ft. is applied to one or both sides of cementable glass supported Teflon tape grades GB-108T, GB-116T or GB-128T. Depending on the weight of copper foil and the Teflon tape grade, the over-all thicknesses run from .006 to .016 in.

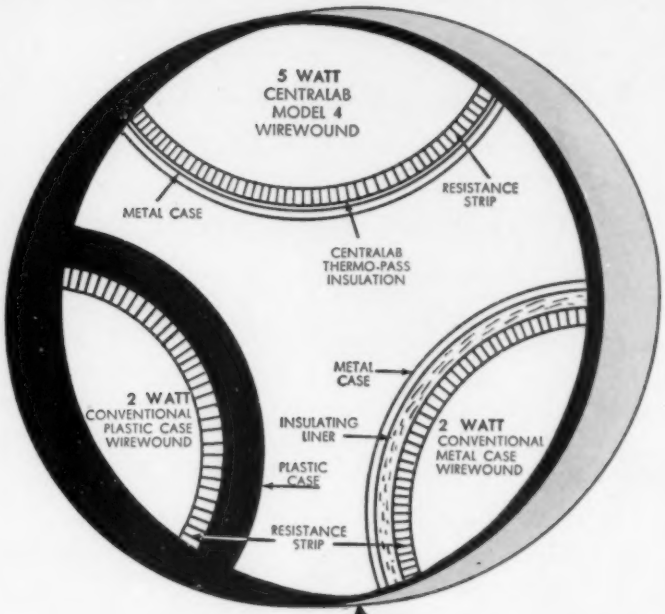
Continental-Diamond Fibre of Canada Ltd., Toronto. (133)

(Continued on page 44)

5 watt capacity — 2 watt size

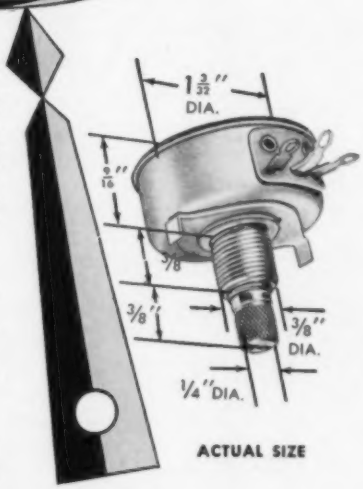
Centralab **MODEL 4**

Miniature Wirewound Radiohms®



As you know, the rating and size of a variable resistor depends upon the speed with which heat can be transferred from the resistance element to the atmosphere. Centralab "thermo-pass" insulation combines exceptional heat transfer with a dielectric strength of 4500 volts per mil at 25° C. Result: Model 4 Radiohm, a conservatively rated 5 watt wirewound variable resistor smaller than a conventional 2 watt unit.

- Only 1 3/32" diameter by 9/16" deep.
- Resistance range, 1 ohm to 15K ohms; linear taper.
- 295° rotation, stop strength 15 inch pounds.
- Minimum life, 25,000 complete cycles.
- Totally enclosed elements.



ACTUAL SIZE

For detailed information write for Centralab Engineering Bulletin EP-493 or contact your Centralab sales representative. Ask your local distributor about the many values he carries in stock in the WW and WN series (listed in Catalog 30).

Centralab Canada Ltd. 804 MT. PLEASANT ROAD TORONTO 12, ONTARIO

8-5810 *Affiliated:* CENTRALAB • MILWAUKEE 1, WISCONSIN

VARIABLE RESISTORS • SWITCHES • PACKAGED ELECTRONIC CIRCUITS
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

Circle No. 18 on Reader Service Card

SSB transmitter for hams has output of 100 watts

Collins 32S-1 single sideband transmitter for amateur radio operators has the following features and specifications. 175 watts pep input; 80, 40, 20, 15, 11, 10 meter bands; upper or lower side band and cw emission; break-in cw; alc; rf feedback; mechanical filter; vox; permeability tuned precision vfo; 100 watts power output; frequency stability, ±100 cps—reset 1 kc; suppression of harmonics and other spurious radiation—carrier —50 db, unwanted sideband—50 db, 3rd order distortion —30 db.

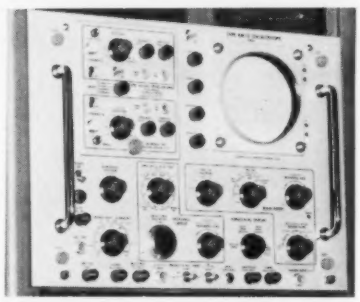
Collins Radio Co. of Canada Ltd., Toronto. (134)

Five new rack mounting oscilloscopes

All Tektronix Type 53/54 Plug-In Units can be used with these five new Tektronix rack-mounting oscilloscopes for complete signal-handling versatility. The oscilloscope cabinets mount in a standard instrument rack, with chassis supported on slide-out tracks. Chassis can be pulled forward, tilted, and locked in any of seven positions for servicing convenience. All five have the same dimensions: 14 in. high, 19 in. wide, 22½ in. rack depth, 24 in. over-all depth.

Type RM45 is electrically identical to the Tektronix Type 545 Oscilloscope. dc-to-30 mc vertical response, wide range of sweep delay. Type RM35 is electrically identical to the Type 535 Oscilloscope. dc-to-11 mc vertical response, wide range of sweep delay. Type RM41 is electrically identical to the Type 541 Oscilloscope. dc-to-30 mc vertical response. Type RM31 is electrically identical to the Type 531 Oscilloscope. dc-to-11 mc vertical response. Type RM32 is electrically identical to the Type 532 Oscilloscope. dc-to-5 mc vertical response.

Tektronix Inc., Toronto. (135)



Electrical grade silicone oil

Union Carbide L-45 silicone oil, electrical grade, is a clear dimethyl silicone polymer for use as an insulating and cooling medium in capacitors, small transformers, circuit breakers and other electrical devices. It is specially dried, packaged and control-tested to insure maximum dielectric strength and volume resistivity. It is available in viscosities of 50, 100 and 1000 centistokes.

Bakelite Co., Toronto. (136)

Cold cathode ionization vacuum gauges

Philips Industries have announced a new line of ionization vacuum gauges of the cold cathode type covering the region 10^{-1} to 10^{-8} mm Hg. Utilization of cold cathode discharge tubes enables the gauges to withstand accidental exposure to atmospheric pressure. These vacuum gauges are suitable for starting a signal or activating a relay when the pressure exceeds a predetermined limit.

Philips Industries Ltd., Toronto. (137)

(Continued on page 45)

CLM RECTIFIERS nurse your batteries

You'll protect your investment in station-type batteries when you install CLM Electronic Regulated Selenium Rectifiers.

CONSTANT OUTPUT VOLTAGE. In a CLM rectifier the output voltage is kept constant from no load to full load which increases battery life.

SELF-PROTECTING. CLM rectifiers are self-protecting on overload as the voltage curve drops off rapidly after 115 percent load is reached. CLM electronic regulated rectifiers are convection cooled, noiseless and require a minimum of maintenance.

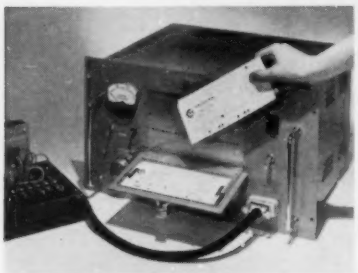
FREE BULLETIN. For your *free* copy of Bulletin SR-14 which describes in detail, the performance characteristics of CLM rectifiers for station-type batteries write: Jack West, Sales Manager, Rectronic Division, **Canadian Line Materials Limited, Toronto 13, Canada.**

CLM **SELENIUM RECTIFIERS**

Circle No. 16 on Reader Service Card

Component tester

Complete tests may be made automatically on transformers, relays, resistors, and other components. Business-machine-punched cards are used in the Component Tester to program the tests on the components. Tests are made on a go/no-go basis with precision bridges used to make the measurements. For each component, the tester either indicates the type of fault or signifies com-



plete acceptance.

Typical test series include: chokes-inductance at rated dc current, and resistance: transistors-cut off current and gain with specified bias input currents.

California Technical Industries, Belmont, Calif. (138)

Servomotors have size 10 frame

Designed for use in miniaturized systems, Muirhead size 10 servomotors have an over-all diameter of 0.940 in. and over-all length of 0.978 in. Weight is 1.45 oz. The stainless steel spindle is hobbed to produce an involute pinion of 13 teeth, 120 D.P., 0.1245″/O. 1240″ O.D., 0.1083″/0.1078″ P.C.D., 20 deg pressure angle.

Two models can be supplied: type F10 m-10-A/1 for 115 v, 400 cps supply and type F 10 m-10-A/2 for 26 v, 400 cps supply. Minimum torque at stall for all models is 0.28 oz. in. Minimum no load speed for all models is 6500 rpm.

Muirhead Instruments Ltd., Stratford, Ont. (139)

Silicone resin for use in paint

Union Carbide R-64 Silicone resin has been designed for cold blending with alkyd, melamine, and acrylic type baking enamels to give them improved color and gloss retention, thermal stability, and resistance to weathering. It can be used as a base for aluminum paints to operate in the 500-1200 F range.

R-64 can also be used to modify baking enamels for use on equipment operating in the temperature range of 300-500 F. Enamels for transformers and motors, high temperature lamps, radio tubes and electrical components are examples.

Bakelite Co., Toronto. (140)

(Continued on page 48)

WE HAVE SYNCHROS AND SERVOMOTORS READY FOR IMMEDIATE DELIVERY

Call Muirheads for an answer to your synchro delivery problems. It's more than likely we have what you want in stock, or, if not, we can give a realistic answer.
The list of synchros in production is extensive and new types are being added all the time. Sizes include 08, 10, 11, 15, 18 and 23; types: Control Transmitters, Control Transformers, Control Differential Transmitters, Resolvers, Torque Receivers, Torque Transmitters, Torque Differential Transmitters and Receivers, Linear Variometers, Servomotors, Motor Tachometers and Tachometer Generators.

It's your move next, let us quote for your needs
Data and prices on request

MUIRHEAD PRECISION ELECTRICAL INSTRUMENTS

MUIRHEAD INSTRUMENTS LIMITED

STRATFORD · ONTARIO · CANADA 3717 & 3718

318/3Ca

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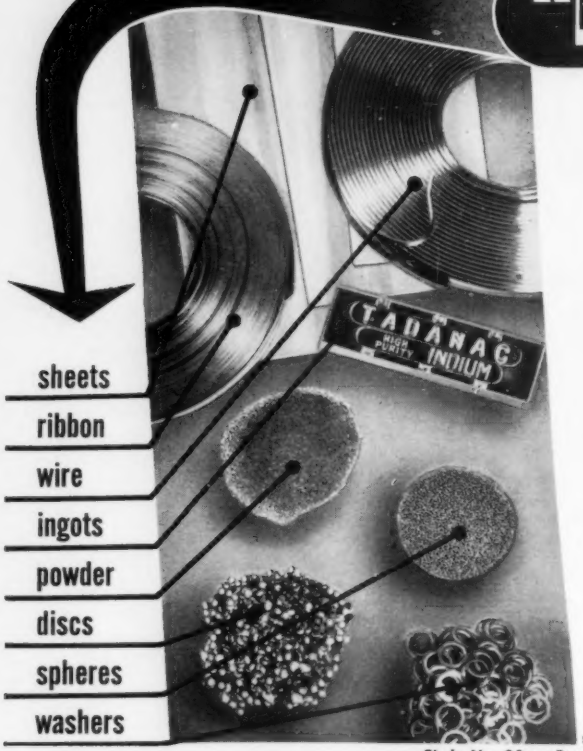
"INDIUM"

and High Purity Metals...



As one of the world's largest primary producers, we are supplying TADANAC Brand Indium and Indium Alloys to leading American, European and Canadian electronic firms. We are in quantity production of the forms shown and are prepared to preform and alloy to your specifications. Our prices include customs duties and we handle all customs procedures. Our Technical Service Department, backed by the full facilities of our Research Division, is ready to assist you in the use of this versatile metal, available as

TADANAC High Purity Indium—99.999% (by diff.)
TADANAC Standard Grade Indium—99.97+%
TADANAC Indium Alloys—a wide range to customer specifications

Other **TADANAC** High Purity Metals
We can supply **LEAD, CADMIUM, SILVER** or **BISMUTH** with a total impurity content of less than 1 p.p.m.* or **ZINC** with a total impurity content of less than 2 p.p.m.*
* Total impurity content determined by spectrographic analysis

For further information and a new booklet on Indium Properties and Uses write:

COMINCO

The Consolidated Mining and Smelting Company of Canada Limited
METAL SALES DIVISION
215 St. James Street, W. Montreal 1, Quebec, Canada

57164 ME

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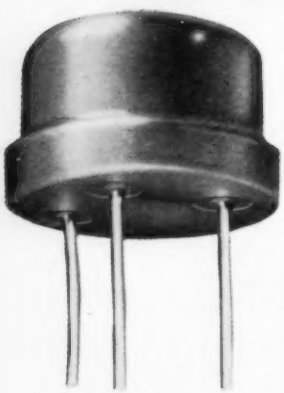
NEW Raytheon Performance - Proved TRANSISTORS

for Superior Reliability . . . Superior Performance



- 0.200" pin circle diameter — ideal for printed circuits.
- Raytheon perfected fusion-alloy process for extreme reliability. Life tests aggregating over 20,000,000 transistor hours show less than one open per 800,000 hours and no shorts.

General Purpose AUDIO

Type	Case	V_{CE} max. volts	Beta ave. small signal	Power Gain Class A ave. db	I_{CO} ave. μa	Noise Factor ave. db	Dissipation Coefficient In Air °C/mw	Dissipation Coefficient In Sink °C/mw
2N422	A	−20	90	40	6	6 max.	0.36	–
2N464	A	−40	22	40	6	12	0.36	0.15
2N465	A	−30	45	42	6	12	0.36	0.15
2N466	A	−20	90	44	6	12	0.36	0.15
2N467	A	−15	180	45	6	12	0.36	0.15
2N130A	B	−40	22	40	6	12	0.59	–
2N131A	B	−30	45	42	6	12	0.59	–
2N132A	B	−20	90	44	6	12	0.59	–
2N133A	B	−20	50	38	6	6 max.	0.59	–
CK754	B	−10	300	45	6	–	0.59	–

General Purpose RADIO FREQUENCY

Type	Case	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	Beta ave.	Cob ave. μμf	r_b'' ave. ohms	Dissipation Coefficient In Air °C/mw	Dissipation Coefficient In Sink °C/mw
2N413	A	−18	2.5	25	12	70	0.4	0.18
2N414	A	−15	6	40	12	80	0.4	0.18
2N416	A	−12	10	60	12	90	0.4	0.18
2N417	A	−10	20	80	12	100	0.4	0.18

Your Design is Better
Your Product performs Better
when you use RAYTHEON SEMICONDUCTORS

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Excellence in Electronics

RAYTHEON CANADA LIMITED
61 Laurel St. East, Waterloo, Ontario.

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ELECTRONIC ENGINEERS

There is a rapidly increasing demand for complex electronic equipment for both military and civilian purposes.

To cope with this demand the Canadian Marconi Company is expanding its activities in the design and development of communication and navigational equipment.

As a result of this expansion we now have a need for fully qualified electronic design engineers to work on the development of the following types of electronic equipment.

LAND MOBILE COMMUNICATION
AERONAUTICAL COMMUNICATION
RADAR
COMPUTERS
MARINE COMMUNICATION
MICROWAVE COMMUNICATION
NAVIGATIONAL AIDS
MICROWAVE TUBE ENGINEERING
RADIO RELAY AND MULTI-CHANNEL ENGINEERING

Starting salary commensurate with education and previous experience.

Applicants should have four or more years previous experience on related work.

Interviews will be arranged promptly. All replies will be treated on a confidential basis.

Send resume showing educational background and previous professional experience to

CANADIAN MARCONI COMPANY

Industrial Relations Division
2442 Trenton Ave.
Montreal, P.Q.

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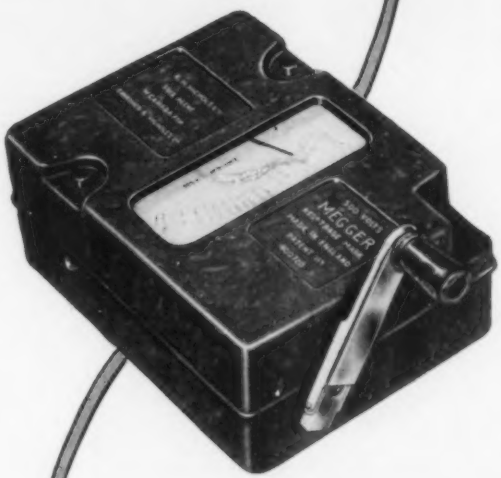
WHY THE

"WEE MEGGER"

INSULATION TESTER IS SO POPULAR



because . . .

- It's pocket-size, easy-to-read, "true" ohmmeter that warns of insulation weakness before breakdowns occur.
- Insulation effectiveness varies with humidity moisture or dirt. A progressive log of insulation behaviour is obtainable by the use of a Megger Tester.
- "Wee Megger Testers" come in three models—100, 250 and 500 volt testing pressures—larger Megger testers too, for whatever your needs.

Write to Dept. EN-3—ask for bulletin 211/3a.

"Megger" is a registered trade mark.

E541

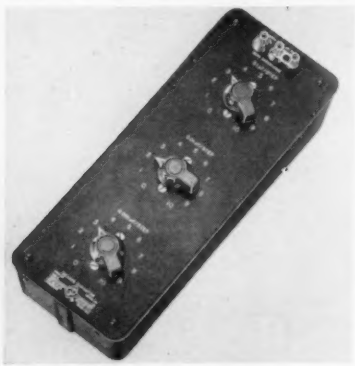
R.H. Nichols LIMITED
2781 DUFFERIN STREET • TORONTO

Circle No. 26 on Reader Service Card

Capacitor decades

Type 980-G and Type 980-H decade capacitance units are new assemblies of the Type 505 capacitors to furnish decades of 0.01 mfd and 0.001 mfd per step respectively. The are suitable for use in ac bridges, resonant circuits and filters.

High-quality silvered-mica sheets, the same material as is used in the 0.1% Type 1409 standard capacitors, are now used in the Type 505 capacitors. Although using the same construction as the standard capacitors, the Type 505's are adjusted to ±0.5%. They are available in a 1-2-5 series extending from 100 mmfd to 0.5 mfd. Dissipation factor for the 1,000 mmfd and higher sizes does not exceed 0.0003. They are housed in low-loss molded-phenolic cases and are equipped with both screw and lug-type terminals and mounting flanges.



General Radio Company, Toronto. (141)

Measuring system uses gamma rays

Gamma ray transmission from radio isotopes is used to measure and control fluid density, specific gravity, percent solids or related quantities in liquids, slurries or divided solids. The measuring head is constructed of heavy corrosion - resistant meehanite castings welded on a section of pipe. Pipe sizes from 3″ to 8″ are standard with other sizes available on special order.

Depending upon the process and material measured, long term accuracies of ±0.001 to ±0.003 specific gravity are obtainable. This system can be furnished with sensitivities to the order of 0.0001 specific gravity. Built-in standardizing circuits maintain accuracy and calibration, and any component except radiation source or detector may be replaced without affecting calibration.

AccuRay of Canada Ltd., St. Lambert, Que. (142)

(Continued on page 52)

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- **Circle the key number on one of these cards**
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Keep your reference shelf up to date this easy way. All advertisements, new products and literature in this issue have a key number. For more information.....

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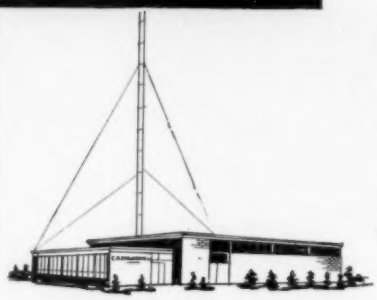
QUARTZ CRYSTALS and CRYSTAL OVENS by SNELGROVE



Licensed under Bell system patents.

A Canadian owned, owner operated company with an enviable reputation for service and quality.

C. R. SNELGROVE CO. LIMITED

141 Bon Ave., Don Mills, Toronto, Ont.

CANADA'S FOREMOST FREQUENCY CONTROL SPECIALISTS

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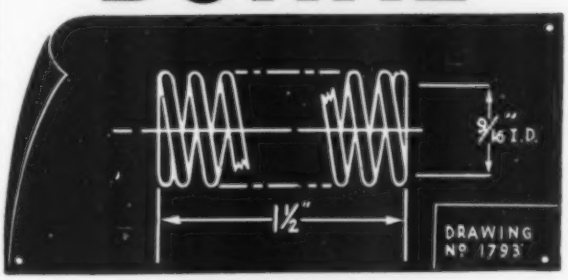
If you wish to obtain further information on any of the advertisements or editorial items appearing in this issue, please make use of our Reader Service card on pages 49 & 50

BOHNE



springs for industry

Send blueprint, specifications or sample for quotation

BOHNE INDUSTRIES LIMITED

1153 QUEEN ST. W. TORONTO

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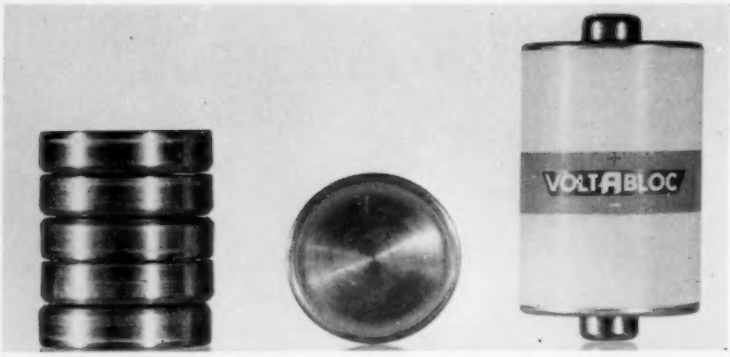
Nickel cadmium button cells have sintered plates



Nickel-cadmium button cells with sintered plates have been developed for miniature and subminiaturized electrical and electronic applications. They are rechargeable, hermetically sealed, have low internal resistance and will not gas upon recharging. Operating at normal temperature ranges, the cells are available in 0.25 ma hour and 0.5 ma hour sizes, each with a nominal voltage of 1.2 volts. Two or more cells can be stacked to obtain a battery of any desired voltage. The cells are recharged by a constant current equal to 1/13 of their normal capacity. It requires 15 hours to recharge the BC 0.25 after discharge, and 13 hours to recharge the BC 0.5. For short periods of time, current up to 15 times the nominal value of the cell can be withdrawn. The BC 0.25 provides 250 ma hours of energy. It is 1⅜ in. in diam., 3/16 in. thick and weighs approximately ½ oz. The BC 0.5 provides 500 ma hours, is 1⅜ in. in diam. and 5/16 in. thick. It weighs approximately ¾ oz.

Ward Leonard of Canada Limited, Toronto. (143)

Silicon full wave bridge rectifier

Type T10A 200 full wave bridge rectifier uses silicon elements and has an output of 10 amps, 200 volts peak. It is designed for use with convection ventilation but can be operated at 150 C with a 10% derating. Reverse leakage at normal ambient should not exceed 20 microamps and the silicon elements are hermetically sealed within the capsule. The rectifiers are available for both single and three phase operation and have physical dimensions of 3 in. x 3 in. x 3 in. Weight is 7 oz.

Taylor-Leslie Mining & Engineering Corp. Ltd., Toronto. (144)

Twin chart recorder

Two type CH recorders have been combined in a single case measuring 19 x 16 3/16 in. for standard 19-in. rack mounting. 28 different chart speeds are available ranging from ¼ in. per hour to 120 in. per min. The chart carriages are driven by a single drive motor located in the right hand carriage. Separate, double speed drive motors are provided for chart speeds of 30, 60, 90 and 120 in. per min.

Canadian General Electric Co. Ltd. (145)

ELECTROLYTIC CAPACITORS

Type PC heavy gauge steel case with screw terminals and mounting lugs. High reliability under extreme conditions. Full range of capacities and voltages.

Canadian Sales Representative
WM. T. BARRON
939 Lakeshore Road — Toronto 14, Ont.

DALY CAPACITORS LIMITED
FORMERLY DALY-ARROW LIMITED
Manufacturers of Electrolytic Capacitors
140 KENDAL AVE. TORONTO 4, ONT.

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There is no need to tie up your technical staff with a publication burden. Our writers and illustrators take over the entire problem with a minimum of effort on your part.

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F V

F. V. TOPPING • *Electronics Ltd.*

DESIGN — PRODUCTION — ELECTRONICS

- RADIO FREQUENCY CONTROL EQUIPMENT
- COMMUNICATIONS ACCESSORIES
- CAREFUL CUSTOM PRODUCTION
- TRANSISTORIZED EQUIPMENT
- SILICON RECTIFIER SUPPLIES
- STABLE AIRBORNE AC SUPPLIES

A CANADIAN COMPANY WITH NEW IDEAS

94 LAIRD DRIVE HU. 9-4325 TORONTO 17, ONTARIO

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New HI-SPEED
MUTUAL CONDUCTANCE
TUBE TESTER

STARK Model 8-77
Portable — Only 16 lbs.

Exclusive: **NEW METHOD OF CALIBRATION**

Voltages are precision calibrated, thus assuring the testing of tubes with professional accuracy, with the time-proven Stark-Hickok method of Dynamic Mutual Conductance — in line with the approved Canadian Armed Forces accepted methods.

Exclusive: **NEW SOCKET DESIGN**

Supplied with snap-in master socket panel, easily and quickly removed to expose new type 11-pin socket that saves time in replacing worn out sockets, and will take other adaptors for checking foreign and older, seldom used, types.

Exclusive: **NEW HIGH SPEED EXTRA SENSITIVE SHORT TEST**
(12 times more sensitive)

Five neon lights automatically indicate shorts or leakage between elements and identify which are shorted.

Exclusive: **NEW GRID CURRENT (GAS) TEST**

The gas content (grid current) is measured very accurately in terms of microamps.

NEW FILAMENT CONTINUITY TEST — As soon as the tube is plugged into test socket, depressing of Filament Continuity button, immediately determines if filament "open" or not.

RESERVE CATHODE CAPACITY TEST — Reserve capacity of tube under test can be determined to weed-out tubes which could cause trouble in the near future.

FILAMENT VOLTAGES—In 18 steps from 0.6 to 117 volts.

SCALE READING IN MICROMHOS — Read directly on the 3-range micromho scales (0 to 3,000, 6,000, 15,000)

Write for full particulars

STARK *fine instruments*

STARK ELECTRONIC INSTRUMENTS LTD.
Factories and Sales Office: Ajax, Ont.
Foreign Division: 276 West 43rd Street
New York 36, N.Y., U.S.A.

Circle No. 30 on Reader Service Card

Charter awarded IRE student associate branch at Ryerson

Chairman Bill Roberts shows new IRE student associate branch charter to fellow students from Ryerson Institute

February 13th was a lucky day and a happy day for the students of Ryerson Institute of Technology, Toronto. Recognition of the important role they are playing in the electronics industry came with granting of a charter to their IRE Student Associate Branch.

This was also a happy day for Eric Palin of Ryerson who first conveived the idea of student associate branches for institutions offering technical courses. That was in 1954 while he was serving as chairman of the Toronto Section. The following year, Frank Pounsett, No. 8 Region director, added his support, and last April the IRE board of directors finalized the scheme. Any recognized institution offering three year diploma technical courses may apply for charter.

Ryerson is the third technical school to receive a charter, following Central Technical Institute in Kansas City and Wentworth Institute in Boston. With more than 300 active student members already enrolled, however, they can claim to be the largest group at the present time.

It is an active group, too. Regular monthly meetings are held to discuss technical problems and listen to speakers from various branches of the industry. But all the speakers are not outsiders. The students have keen public speaking competitions.

Satellite saves face

Shortly after the successful launching of Explorer I, an American radio announcer stated that the project was designed to provide scientific information on such things as cosmetic rays. Maybe they can be used to "make up" for lost time?

Watch for more use of industrial TV

Industrial closed circuit television has been feasible for some time now, but industry, so far, has been slow to make use of it. With smaller, more reliable equipment coming on the market, buyers should show more interest; and with other markets, such as commercial TV and defense at low ebb, manufacturers are stepping up their sales campaigns.

Editor Harold Price will present a symposium on industrial TV in the April issue of CEE, showing the types of equipment available in Canada and some of the many applications.

Part two of the series on technical writing has been prepared by Jack Konigsberg to show how the technical writer can become a valuable member of a research team.

Some of the latest techniques and equipment used in the production of printed circuits also will be discussed in April.

COMING EVENTS

March

17-21 EJC Nuclear Congress. Chicago.

24-27 Radio Engineering Show & IRE National Convention. New York.

April

14-16 AIEE-IRE-ASME Automatic Techniques Conference. Detroit, Mich.

14-17 15th Annual Radio Component Show. Grosvenor House and Park Lane House, London, W.1.

16-25 Instruments, Electronics & Automation Exhibition. Olympia, London.

May

12-14 National Aeronautical & Navigational Electronics Conference. Dayton, Ohio.

19-21 Electronic Parts Distributors Show, Chicago.

21-23 Engineering Institute of Canada annual meeting. Quebec.

June

9-11 Canadian National Business Show. Exhibition Park, Toronto.

22-27 AIEE Summer General Meeting. Buffalo, N.Y.

Students prove to be excellent speakers

Each year, as the days begin to stretch out a little and a faint image of spring exams appear on the horizon, a new crop of butterflies flutter through the stomachs of students. This is the public speaking species, nurtured by the competitions for student members of the various technical societies.

It takes a lot of courage to stand up in front of a large audience, but the experience is well worth the twenty minutes of trembling knees, dry throat and cold perspiration. The audience is seldom aware of these inner tensions. For them it is a rewarding evening listening to papers that have been well prepared and well delivered.

This year at the University of Toronto, four excellent papers were delivered at the joint IRE-AIEE student competition. The same thing has taken place, or will soon take place at other universities across Canada. Graduates, particularly those contemplating delivering papers at society meetings, would do well to take a few pointers.

Winner of Toronto IRE-AIEE student speaking contest was M. H. Allison

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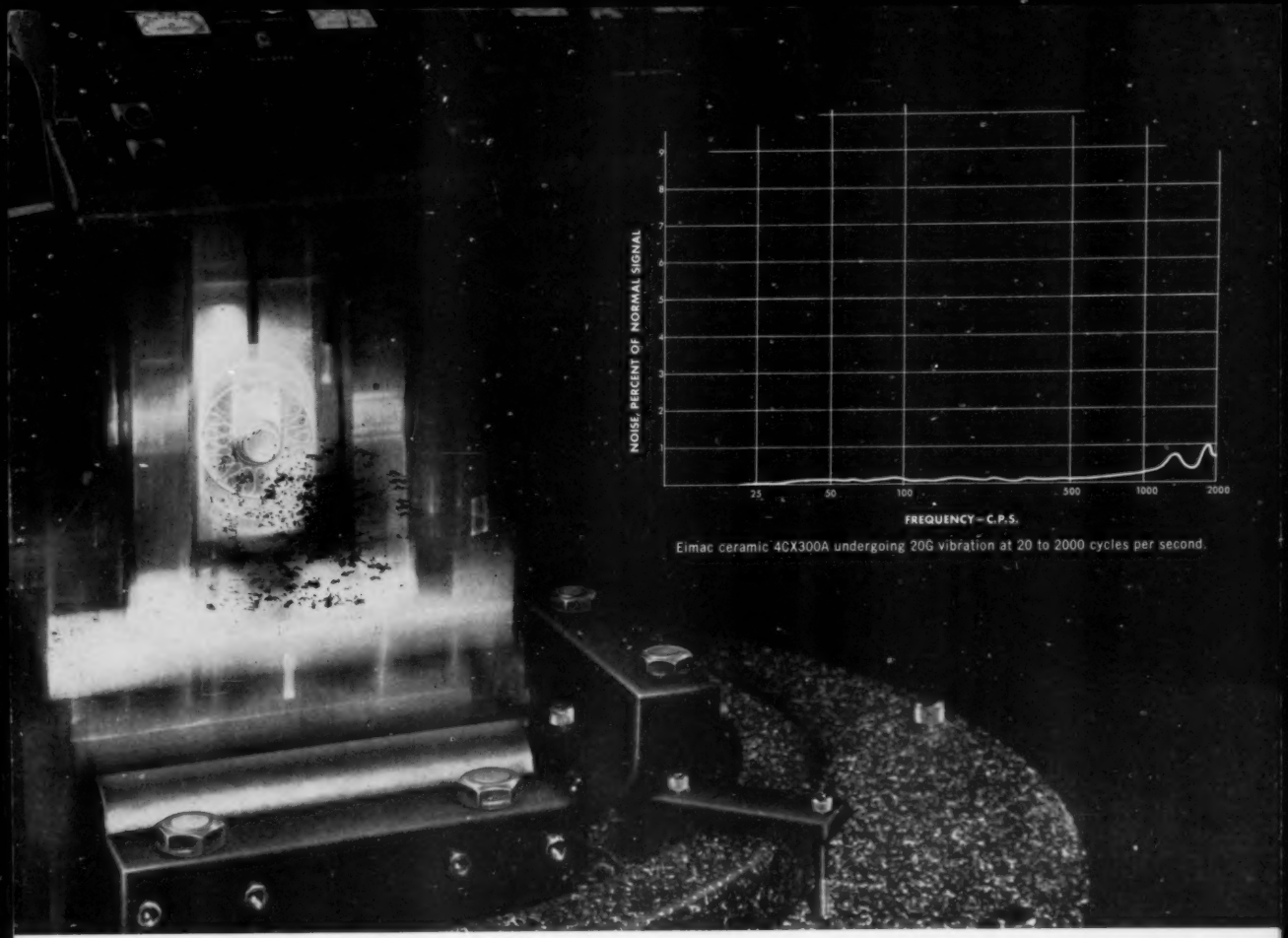

Eimac ceramic 4CX300A undergoing 20G vibration at 20 to 2000 cycles per second.

Third in a series describing the advantages of ceramics in electron tubes. Previously discussed: impact and heat.

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In the illustration an Eimac ceramic 4CX300A, 300 watt tetrode, is being operated in a circuit while undergoing 20G vibration at 20 to 2000 cycles per second. The exceptionally low noise level, produced under these conditions shown in the graph above, remains less than 1% of normal signal over the entire test range.

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